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Mathematical Achievement as a Proxy for Measuring Quality of Education among Non-Native English Speakers

التّحصيل الرّياضيّ مؤشّرًا لقياس جودة التّعليم لدى غير النّاطقين بالإنجليزيّة

Ahmed F. Fasfous, Natalia Hidalgo-Ruzzante , Raquel Vilar-López, Mario Gálvez-Lara, and Miguel Pérez-García.

Abstract

This study aims to examine the role of mathematical achievement in explaining cultural differences in neuropsychological performance. A comprehensive neuropsychological battery was administrated to 54 individuals from two different cultures: (27 Spaniard and 27 Colombians). Several studies have demonstrated that the quality of education measured by reading ability tests may explain cultural differences in neuropsychological test performance. These studies have been conducted mostly among English speakers within the same educational system. Being a non-phonemic language, English allows for the reading of low-frequency words to be used as a measure of the quality of education. However, this might not be useful in the case of phonemic languages, such as Spanish. Moreover, it is difficult to compare the quality of education measured by reading ability in cultures with different languages or different educational systems. The results of this study reveal significant differences between these group on the majority of neuropsychological tests. All these differences disappeared when the effect of mathematical achievement was controlled. Thus, mathematical achievement may be considered as a measure of quality of education when studying cultural neuropsychological differences.

Keywords: Culture; Neuropsychological Assessment; Mathematical Achievement; Quality of Education; Spanish

الملخص

يهدف هذا البحث إلى دراسة دور التّحصيل الرّياضيّ في تفسير الفروق الأدائيّة في اختبارات علم النّفس العصبيّ لدى مجموعة من الأشخاص المنتميين لثقافات مختلفة. وتكونت عينة الدراسة من أربعة وخمسين (٥٤) مبحوثا (٢٧ من إسبانيا و ٢٧ من كولومبيا) طبقت عليهم بطارية اختبارات نفسية-عصبية شاملة. فقد أظهرت عديد من الدراسات النّفسيّة أن جودة التعليم قد تفسر الفروق الثقافية الحاصلة في نتائج اختبارات علم النفس العصبي. وهي التي تقاس عادة من خلال القدرة على القراءة. ذلك أنّ معظم هذه الدراسات أجريت على أشخاص يتحدّثون اللّغة الإنجليزيّة ممّن تلقوا تعليمهم ضمن النّظام التّعليميّ نفسه. نظرًا لكون اللّغة الإنجليزيّة من اللّغات غير الفونولوجيّة (الصّوتيّة)، فهذا يجعل من اختبارات القدرة على القراءة أداة لقياس جودة التّعليم. وهذه الطريقة قد لا تكون مناسبة لقياس جودة التّعليم لدى النّاطقين باللّغات الفونولوجيّة كاللّغة الإسبانية مثلا. إضافة إلى ذلك، فإنه من الصعب استخدام القدرة على القراءة أداة لقياس جودة التّعليم عند المقارنة بين أشخاص ينتمون إلى دول وثقافات مختلفة، وهم الذين يتحدثون لغات مختلفة ويتعرضون لأنظمة تعليميّة مختلفة. أظهرت نتائج هذه الدراسة وجود فروق ذات دلالة إحصائية بين المجموعتين في معظم الاختبارات المستخدمة. علمًا بأنّ هذه الفروق تلاشت بعد ضبط أثر التّحصيل الرّياضيّ على نتائج الاختبارات. وبهذا فإننا نوصي باستخدام اختبارات التّحصيل الأكاديميّ مؤشّرًا لجودة التّعليم، وخاصّة عند دراسة الفروق الثقافيّة في الأداء النّفسيّ العصبيّ.

الكلمات المفتاحيّة: ثقافة، تقييم نفسي-عصبي، تحصيل رياضيّ، جودة التّعليم، اللّغة الإسبانيّة

Introduction

There is clear evidence that cultural variables affect neuropsychological performance. Therefore, these variables should be considered in the neuropsychological assessment of individuals from different cultures and/or ethnic backgrounds (Ardila, 2005, Ardila & Moreno, 2001; Baird, Ford, & Podell, 2007; Buré-Reyes et al., 2013; Byrd, Touradji, Tang, & Manly 2004; Gasquoine ,1999; Patton, Duff, Schoenberg, Mold, Scott, & Adams, 2003; Ramírez, Ostrosky-Solis, Fernández, & Ardila, 2005; Puente, Pérez-García, Vilar-López, Hidalgo-Ruzzante, & Fasfous, 2013). Researchers have found differences among individuals from different cultural backgrounds on both verbal and non verbal neuropsychological test performance (Agranovich, Panter, Puente & Touradji, 2011; Boone, Victor, Wen, Razani, & Pontón, 2007; Fasfous, Hidalgo-Ruzzante, Vilar-López, Catena-Martínez, & Pérez-García, 2013; Manly, Jacobs, Touradji, Small, & Stern, 2002; Rosselli & Ardila, 2003).

These differences have traditionally been explained by variables such as education attainment, socioeconomic status, and ethnicity (e.g., Armengol, 2002; Boone et al., 2007; Byrd, Sánchez, & Manly, 2005; Rosselli & Ardila, 2003). However, when variables such as language (background), illiteracy, bilingualism, or socioeconomic status are controlled for, differences in neuropsychological performance decrease (Brickman, Cobo, & Manly, 2006; Manly, 2008; Rivera-Mindt et al., 2008; Schwartz et al., 2004).

Research indicates that acculturation also could explain the cultural differences in neuropsychological performance (Boone et al., 2007; Byrd et al., 2005; Cofffey, Marmol, Schock, & Adams, 2005; Kennepohl, Shore, Nabors, & Hanks, 2004; Razani, Burciaga, Madore, & Wong, 2007). Furthermore, researchers have begun to consider new culture-specific variables, such as time attitude. Agranovich and colleagues (2011) found that differences between American and Russian adults in Timed Neuropsychological scores could be explained by culture-specific time attitudes. Despite such results, additional research is needed to understand how cultural variables may influence neuropsychological performance.

Problem Statement

The quality of education seems to be a promising variable that can explain cultural differences in neuropsychological studies (Byrd et al., 2005; Manly, Byrd, Touradji, & Stern, 2004; Manly et al., 2002; Schneider & Lichtenberg, 2011). Several studies demonstrated that the quality of education measured by reading ability tests could explain cultural difference in neuropsychological test performance more than education attainment (Manly et al., 2002; 2004). Specifically, Manly and colleagues (2002) found that differences in various neuropsychological tests between White non-Hispanic and African American disappeared after controlling their level of reading. Nevertheless, these studies have mostly been conducted among English-speaking elders coming from the same educational system. As English is a non-phonemic language (that is, the same letter has different pronunciations in different words, without fixed rules), reading low-frequency words can easily be understood as a measure of the quality of education. However, this factor might not be useful for phonemic languages, such as Spanish. Moreover, it is difficult to compare the quality of education in cultures with different languages or different educational systems.

Present Study

PISA (Programme for International Student Assessment) is an international program to evaluate the quality of education systems in over 65 countries (OECD, 2012). In this program, experts use measures for reading, mathematics and science achievement as indicators for quality of education to compare 15 year-old students around the world (OECD, 2012). In adults, PIAAC (Programme for the International Assessment of Adult Competencies) uses both reading and mathematics achievement to assess adult skills (Ministerio de Educación, Cultura y Deporte, 2013). In neuropsychological studies, reading ability has been widely used as a proxy for education quality while mathematic skills have not. To our knowledge, no studies have examined the effect of the quality of education, as measured by reading and mathematics achievement on the neuropsychological performance of individuals from different educational systems.

In summary, although the impact of reading ability on various neuropsychological tests was studied, the role of mathematical ability has not been examined. Therefore, the aim of this research is to study the role of mathematical achievement in explaining the neuropsychological differences between different cultural groups.

Method

Participants

A total of 54 healthy participants (24 male and 30 female) from Spain (N=27) and Colombia (N=27), all of them residing in Spain, volunteered to participate in the present study. The participants were recruited from various non-profit organizations working with immigrants in Granada and from the University of Granada's student body. Thus, the participant groups were composed of individuals who shared the same language background, i.e. Spanish, but who had different cultural backgrounds.

The age of participants ranged between 18 and 55 years. Most (92.6%; n=52) of the sample had a medium-high level of education. As an exclusion criterion, we considered the participants' previous history of mental disorders, neurological disorders and substance abuse. (The information was elicited during an interview.) The history of mental disorders was taken into consideration if participants had suffered any kind of psychopathological disorder. This was measured during the initial interview by asking them about previous visits to mental health professionals and their experience taking psycho-drugs in the past or present. The existence of neurological disorders was also measured in the same interview by asking the participants about their history visiting neurologists or taking nerve medications. The number of months Colombians had resided in Spain ranged from 3 to 132 months (M=41.22; SD= 40.67), and this was used as an indicator of acculturation.

Instruments

In order to examine our hypothesis, we assessed the quality of education using the *Batería Woodcock-Muñoz Psicoeducativa en Español (*Woodcock, 1982); **Achievement in mathematics** was assessed using the Calculation subtest, and **reading comprehension** was measured by the Reading Comprehension subtest. The Batería Woodcock-Muñoz was originally adapted for Spanish, Colombian and other Spanish speakers. In this test, the actual dialect of Spanish used by the individual participants was taken into account by the variety of possible correct answers for each question that was allowed.

We designed a comprehensive neuropsychological battery with tests typically utilized in our laboratory, and commonly used for the Spanish population. Moreover, most of these instruments had been previously used in neuropsychological cross-cultural studies (Agranovich & Puente, 2007; Bakos, Denburg, Fonseca, & Parente, 2010; Boone et al., 2007; Ostrosky-Solis,

Lozano Gutierrez, Ramirez Flores & Ardila, 2007). To avoid interference between tests, the order of testing was set according to Lezak, Howieson and Loring (2004, pp. 115).

The battery measured the following domains: **Perception**: The *Hooper Visual Organization Test (HVOT*; Hooper, 1958; revised in 1983); **Visual motor coordination**: The *Color Trail Test A (CTT-A*; D'Elia, Satz, Uchiyama, & White, 1996); **Attention:** Brickenkamp's *Test of Attention (d2)* (1962); *Verbal Memory:* The *Hopkins Verbal Learning Test (HVLT*; Benedict, Schretlen, Groninger, & Brandt, 1998). The Spanish version of this test was published by Bilbao et al. (2007); *Visual Memory:* The *Rey Complex Test and Figure Test and Recognition Trial (ROCFT;* Meyers & Meyers, 1995); *Updating/Working Memory:* The *Semantic Verbal Fluency* test (*SVF;* Valencia et al., 2000), The *Ruff Figural Fluency Test (RFFT*; Ruff, 1996), The *Backward Digit Span (WAIS-III*; Wechsler, 1999); *Flexibility:* The *Color Trail Test B (CTT-B*; D'Elia et al., 1996); *Decision-making:* The *Iowa Gambling Task (IGT*; Bechara, Damasio, Damasio, & Anderson, 1994).

Procedure

The total duration of the evaluation was approximately two and a half hours per participant. This time included a 15-minute break at the middle of the session, and an initial interview to collect socio-demographic information and acculturation, and to guarantee the inclusion/exclusion criteria.

The participants received verbal and written information about the study objectives and details, and signed an informed consent form. The study was approved by Ethics Committee of the University of Granada. The volunteers received 20€ for participating in this study.

Statistical Analysis

Student's t test was conducted on the Continuous variable of age. Chi-square tests were conducted on the Ordinal variables of gender, income level, and education level to examine differences in these variables among the two groups.

Pearson's Correlations were used to determine the correlation between acculturation and neuropsychological scores. Since the results demonstrate no significant correlation between them, acculturation was not considered for further analysis.

To analyze the differences in performance between groups on the neuropsychological test battery, *Student's t- test* was also used. When these *t* tests revealed a difference in

neuropsychological performance among groups, linear regressions were performed using both reading and math achievements separately as predictors (independent variable) and the neuropsychological score as a dependent variable. Then, standardized residuals of the neuropsychological test scores were saved, and differences between groups on the residuals were examined using *t* tests.

Results

The results showed that there were no differences between the Spanish and the Colombian groups according to age, gender, educational level, and monthly income (see Table 1).

Table 1. Descriptive statistics for the two groups on the sociodemographic variables

	Spaniards (n=27)	Colombians (n=27)	t/χ2	*p*
Sex			.670	.41[1]
Male	48.1% (13)	40.7% (11)		
Female	51.9% (14)	59.3% (16)		
Age (years)	25.63 (3.33)	29 (7.17)	1.946	.06[2]
Education			5.33	.15[1]
Elementary education	0% (0)	7.4% (2)		
Secondary education	11.1%(3)	22.2% (6)		
Undergraduate education	55.5% (15)	29.6% (8)		
Graduate education	33.4% (9)	40.7% (11)		
Income/ month				
- Less than 360€			.297	.79[1]
- Between 361€-900€				
	48.1% (13)	57.7% (15)		
	51.9% (14)	42.3% (11)		

[1] Chi-square test
[2] t test

Differences in neuropsychological test performance

The results showed significant differences between the Spanish and Colombian groups on the majority of the neuropsychological tests. The Spanish group had higher scores than the Colombians on tests of perception (HVOT), visuomotor coordination (CTT-A), attention (d2), visual memory (delayed recall of ROCFT), and on 4 of the six executive function tests (animals, RFFT, CTT-B, and total score in IGT). However, there were no differences between the two groups on the verbal memory test (HVLT), semantic fluency (fruits), and working memory (BDS) (see Table 2).

Effects of reading comprehension and mathematics achievement on neuropsychological performance

Finally, we studied the differences between the two cultural groups when the effect of reading comprehension (residuals) was controlled. The results showed that differences among groups disappeared in visual memory (ROCFT-DR), non verbal fluency (RFFT) and semantic fluency (animals). On the other hand, all the differences between the Spanish and Colombian groups on neuropsychological tests (except for CTT-B) disappeared when the effect of math achievement was controlled using the standard residuals (see Table 2).

Table 2. Neuropsychological tests performance by ethnicity

Function	Task	DV	Colombian M (SD)	Spanish M (SD)	t	*p*	*p* Read. adjusted	*p* Math adjusted
Perception	HVOT	Total	23.63 (4.33)	26.72 (2.04)	-3.59	**.002**	**.022**	.129a
Motor	ROCFT	Copy	34.89 (1.55)	35.3 (1.08)	.48	.192	.382	.953
	CTT-A	Time	45.52 (14.77)	33.04 (10.28)	3.60	**.001**	**.027**	.102[a]
Attention	D2	Hits	153.48 (38.74)	188.30 (39.04)	-3.29	**.002**	**.005**	.202[a]
		CON	151.07 (39.55)	187.52 (39.6)	-3.38	**.001**	**.004**	.195[a]
Memory	ROCFT	DR	23.17 (6.95)	27.46 (4.43)	-2.71	**.010**	.058[a]	.418[a]
	HVLT	IR	7.04 (1.81)	7.22 (1.65)	-.39	.696	.521	.883
		DR	9.67 (1.52)	10.26 (1.74)	-1.33	.189	.631	.581
		Total	26.74 (4.19)	28.63 (3.96)	-1.70	.095	.294	.762
Executive Functions	RFFT	Total	83.85 (26.72)	100.22 (17.60)	-2.66	**.010**	.111[a]	.440[a]
	Animals	Total	21.89 (4.79)	25.23 (5.54)	-2.26	**.028**	.074[a]	.888[a]
	Fruits	Total	15.89 (3.37)	14.41 (3.14)	1.58	.122	.085	.065
	BDS	Total	6.07 (2.20)	7.04 (1.7)	-1.80	.078	.226	.798
	CTT-B	Time	89.33 (28.23)	64.11 (12.32)	4.25	**<.001**	**.004**	**.009**
	IGT	Total	3.75 (21.89)	24.74 (27.76)	-2.97	**.005**	**.040**	.245[a]

NOTE: DV= Dependent Variable, ROCFT= Rey Complex Figure Test, CTT= Color Trail Test, RFFT= Ruff Figural Fluency Test, SVF= Semantic Verbal Fluency, d2= d2 Test of Attention, HVLT= Hopkins Verbal Learning Test, HVOT= Hooper Visual Organization Test, IGT= Iowa Gambling Test, DR=Delayed Recall, CON= Concentration Index, IR= Immediate Recall, , C= Colombians, M= Moroccan, S= Spaniards. BDS: Backward Digit Span; a no significant differences after reading or math adjustment.

Discussion

Differences were found between the Spanish and Colombian groups in performance on the majority of the neuropsychological tests used in this study. Moreover, our results demonstrate that quality of education measured by mathematics achievement could explain these differences. Although study groups were matched for age, gender, educational level and socioeconomic status, differences in neuropsychological performance between the two groups were quite clear. This finding is similar to that of other studies, which likewise find that individuals from diverse cultures perform differently in neuropsychological tests (Agranovich et al., 2011; Ardila & Moreno, 2001; Baird et al., 2007; Byrd et al., 2004; Gasquoine, 1999; Ramírez et al., 2005). However, our data addresses issues that have been rarely considered in previous studies. First, we focused on participants who had a medium-high degree of education instead of those with a low level of education. Second, many prior studies were limited because they only examined specific neuropsychological areas (Byrd et al., 2004; Ostrosky-Solis & Lozano 2006; Ramírez et al., 2005), and they did not study neuropsychological performance exhaustively using a complete battery of tests. Third, we have included new cultural groups who are seldom studied, such as Spaniards and Colombians. These two groups speak Spanish but have different education systems and different cultural backgrounds.

In our study, mathematical achievement played an important role in explaining the differences between the Spanish and Colombian groups in neuropsychological performance, so that differences on all neuropsychological tests (except for CTT-B) disappeared after controlling for that variable. On the other hand, when reading comprehension was controlled, differences remained on 6 of the nine tests. Calculation skills in different cultures differ depending on the educational system (Tang et al., 2006) or culture-specific variables (Cambell & Xue, 2001; Ng & Rao, 2010). Thus, this variable could be understood as an indicator of the quality of education, and it could account for the neuropsychological differences found between cultures.

The quality of education depends on the educational system which exists in a country and which usually varies from one country to another. As educational systems are varied, it is a challenge to compare the quality of education in individuals from different countries. PISA is the only international project around the world designed by professionals from different countries to evaluate the quality of education in a cross-cultural context. In this project, Mathematics, reading, and science achievement is used to measure the quality of education

among people in cross-cultural contexts. We suggest that neuropsychologists use this type of information in their own work.

Nevertheless, it is important to take into consideration that calculation achievement should not be used as a measure for the quality of education among patients with brain damage in areas related to calculation ability. In the same way, reading ability cannot be used to measure quality of education in patients with a language disorder. However, both measures are applicable in studies conducted on healthy people from different cultural backgrounds. At the same time, we believe that reading ability cannot be used to measure the quality of education in participants who speak phonemic languages or who belong to different educational systems. Thus, calculation achievement could be a better proxy for measuring the quality of education in this case.

The present study has some limitations. Due to the long duration of assessment (2 h 30 m per participant), the sample had to be kept relatively small. Furthermore, all participants included in this study were healthy; it would be useful to study if our results replicate in clinical samples. Future studies with large sample sizes, and participants of different educational levels, socioeconomic status, and cultures could be helpful to understand the role of calculation skills in explaining cultural differences in neuropsychological performance. Finally, this is an observational preliminary study that will be completed in future research. The final limitation of the study regards the study sample. As the sample was restricted by the main aim of the study, it cannot be considered representative of Colombian immigrants in Spain.

In our study mathematics achievement was found to be a valuable measure for the quality of education. It is recommended that future studies should consider assessing calculation skills, especially when comparing the quality of education in non-English speakers and/or people from different education systems.

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