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F. Ostrosky-Solís [a], M. Ramírez [a], A. Lozano [a], H. Picasso [a] & A. Vélez [a]
[a] Universidad Nacional Autónoma de México, Lomas de Reforma, México

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Culture or education? Neuropsychological test performance of a Maya indigenous population

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Universidad Nacional Autónoma de México, Lomas de Reforma, México

Although culture and education are factors that significantly affect cognitive performance, it is often difficult to distinguish between the effects of education and the effects of culture, since the educational level influences the sociocultural status of an individual. Therefore, although it is common to attribute the differences between the performance in neuropsychological tests to both the level of education and the culture, frequently the effects of the two variables are confounded. In the present study we analysed the influence of education and of culture on the neuropsychological profile of indigenous and a nonindigenous population. We studied a total sample of 44 individuals divided into 4 groups: (1) 7 illiterate indigenous subjects; (2) 7 control subjects with no education; (3) 15 indigenous subjects with 1–4 years of education; and (4) 15 control individuals with 1–4 years of education. Subjects were paired by age and educational level. The indigenous population was Maya, who live in the state of Yucatan in the Mexican Republic. The NEUROPSI, a brief neuropsychological test battery developed and standardized in Mexico (Ostrosky-Solís, Ardila, & Rosselli, 1997, 1999), was individually administered. Results showed differential effects for both variables. Indigenous subjects showed higher scores in visuospatial tasks, and their level of education had significant effects on working and verbal memory. No significant differences were found in other cognitive processes (orientation, comprehension, and some executive functions). Our data showed that culture dictates what it is important for survival and that education could be considered as a type of subculture that facilitates the development of certain skills instead of others. However, the influences of both variables on cognitive skills are different, which should be considered when assessing subjects of different cultures. The interpretation of neuropsychological tests, leading to accurate assessment of cognitive dysfunction, is dependent on both education and cultural skills.

Quoique la culture et l'éducation soient des facteurs qui affectent de façon significative la performance cognitive, il est souvent difficile de distinguer entre les effets de l'éducation et ceux de la culture, notamment en raison du fait que le niveau d'éducation influence le statut socioculturel des individus. Par conséquent, bien qu'il soit courant d'attribuer les différences entre la performance dans les tests neuropsychologiques à la fois au niveau d'éducation et à la culture, fréquemment, les effets des deux variables sont confondus. Dans la présente étude, nous avons analysé l'influence de l'éducation et de la culture sur le profil neuropsychologique de populations indigènes ou non indigènes. Nous avons étudié un total de 44 individus divisés en quatre groupes: (1) 7 participants indigènes analphabètes; (2) 7 participants contrôle sans éducation; (3) 15 participants indigènes ayant entre 1 et 4 ans de scolarité; (4)15 participants contrôle ayant entre 1 et 4 ans de scolarité. Les participants furent pairés selon l'âge et le niveau d'éducation. La population indigène était constituée de Mayas vivant dans l'état du Yucatan en République mexicaine. Le NEUROPSI, une brève batterie de tests neuropsychologiques développée et standardisée à Mexico (Ostrosky-Solís, Ardila, & Rosselli, 1997, 1999) fut administrée individuellement. Les résultats indiquent des effets différents pour les deux variables. Les participants indigènes ont montré des scores plus élevés dans les tâches visuospatiales et le niveau d'éducation avait des effets significatifs sur le travail et la mémoire verbale. Aucune différence significative ne fut trouvée quant aux autres processus cognitifs (orientation, compréhension et fonctions exécutives). Nos données montrent que la culture dicte ce qui est important pour la survie et que l'éducation doit être considérée comme un type de sous-culture qui facilite le développement de certaines habiletés plutôt que d'autres. Cependant, les influences des deux variables sur les habiletés cognitives sont différentes. L'interprétation des

Correspondence should be sent to Feggy Ostrosky-Solís, PhD, Universidad Nacional Autónoma de México, Rivera de Cupia 110-71, Lomas de Reforma, México, DF 11930 (E-mail: feggy@prodigy.net.mx).

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tests neuropsychologiques et, par conséquent, l'évaluation exacte de dysfonctions cognitives, dépendent à la fois de l'éducation et des habiletés culturelles.

Aunque la cultura y la educación son factores que afectan significativamente el desempeño cognoscitivo, a menudo es difícil distinguir entre los efectos de la educación y los efectos de la cultura, ya que el nivel educativo tiene influencia sobre el estado socio-cultural de un individuo. Por consiguiente, aunque es común atribuir las diferencias del desempeño en una prueba neuropsicológica a ambas, el nivel educativo y la cultura, frecuentemente los efectos de las dos variables son confundidos. En el presente estudio se analizó la influencia de la educación y de la cultura en el perfil neuropsicológico de una población indígena y una población no indígena. Se estudió una muestra total de 44 individuos dividida en 4 grupos: (1) 7 sujetos indígenas analfabetos; (2) 7 sujetos control sin educación; (3) 15 sujetos indígenas con 1–4 años de educación; y (4) 15 individuos control con 1–4 años de educación. Los sujetos fueron pareados por edad y el nivel educativo. La población indígena era población Maya que vive en el estado de Yucatán en la República Mexicana. Se administró individualmente la Batería Neuropsicológica Breve en Español NEUROPSI, desarrollada y estandarizada en población hispano-hablante (Ostrosky-Solís, Ardila, & Rosselli, 1997, 1999). Los resultados mostraron efectos diferenciales para ambas variables. Los sujetos indígenas mostraron las puntuaciones más altas en las tareas visoespaciales, y el nivel de educación tuvo efectos significativos en la memoria de trabajo y en la memoria verbal. No se encontraron diferencias significativas en otros procesos cognoscitivos (orientación, comprensión, y algunas funciones ejecutivas). Estos datos sugieren que cultura dicta lo que es importante para la supervivencia y que la educación podría ser considerada como un tipo de subcultura que facilita el desarrollo de ciertas habilidades en lugar de otras, sin embargo las influencias de ambas variables en las habilidades cognoscitivas son diferentes, por consiguiente esto los datos deben ser considerados cuando se evalué a sujetos de culturas diferentes. La interpretación de pruebas neuropsicológicas y por consiguiente la valoración de los trastornos cognoscitivos depende tanto de habilidades educativas y culturales.

Level of education has been proven to have an important impact on the cerebral organization of cognitive skills and on performance in neuropsychological tests (Ardila, Ostrosky-Solís, Rosselli, & Gómez, 2000; Ardila, Rosselli, & Rosas, 1989; Castro-Caldas, Petersson, Stone-Elander, & Ingvar, 1998; Castro-Caldas & Reis, 2000; Manly et al., 1999; Matute, Leal, Zarabozo, Robles, & Cedillo, 2000; Ostrosky, Canseco, Quintanar, Navarro, & Ardila, 1985; Ostrosky, Quintanar, Canseco, Memeses, Navarro, & Ardila, 1986; Ostrosky-Solís, 2002; Ostrosky-Solís, Ardila, Rosselli, López-Arango, & Uriel Mendoza, 1998; Rosselli, Ardila, & Rosas, 1990). It has been suggested that illiterate people solved cognitive problems functionally and specifically, and responded better to the perceptual and functional attributes of stimuli, whereas educated subjects responded to abstract concepts and to logic relationships between stimuli (Luria, 1976).

Although level of education has a significant influence on the nature of performance on traditional neuropsychological measures of verbal and nonverbal skills, it is often difficult to distinguish between education and culture, since the educational level influences the sociocultural status of an individual. Therefore, although it is common to attribute the differences between performances in neuropsychological tests to both level of education and culture, the effects of the two variables are frequently confounded. As Ardila (1996) pointed out, the differences found in the performance on tests between "Anglos" and "Hispanics" in the United States are frequently attributed to cultural variables, without taking into account that a great part of these differences is simply the result of different educational levels.

Culture has been defined as "the way of living of a human group"; it involves everything we learn as members of a society, whether this is within social, political, economic, religious, and/or linguistic institutions. This learning includes not only the knowledge of skills to survive physically or socially, but even how to express emotions, appreciate music, or experience pain (Chinoy, 1992). Although culture is an important variable involved in the development and use of specific cognitive and behavioural skills, currently there are very few studies that have analysed how culture influences neuropsychological performance. Recently, Ardila and Moreno (2001) evaluated a group of Arauco indigenous in Colombia, using a neuropsychological test battery. Twenty indigenous were selected, 12 male and 8 female; the age range was between 8 and 30 years, and education level between 0 and 6 years. The adults were monolingual (indigenous language) and illiterate; the minors were bilingual and educated. The battery with which they were assessed included copying a cube, copying and recalling the Rey-Osterrieth figure, the Spanish version of the WISC-R block design, identification of overlapped figures, identification of multiple-choice figures, ideomotor praxis, drawing a map, spatial memory, verbal fluency, modified Wisconsin card, and a laterality questionnaire. The authors report that in some of the tests, the performance of the indigenous group was almost perfect (identification of overlapped figures and ideomotor praxis skills), whereas performance in other tests was impossible (cubes design, map drawing, Rey-Osterrieth complex figure copying, and spatial memory, modified Wisconsin). They concluded that three variables affected the performance of the subjects. (1) Educational level: A significant correlation between the scoring in the test and this level was found. (2) Cultural relevance: Some tests were significant and important while others did not make sense and were impossible to understand. (3) Age: A significant association was found between performance in the tests and this variable. One of the limitations of this study is that it included a small sample of subjects ($n = 20$) with different levels of education (0–6 years) and a wide range of ages (8–30 years), and therefore it is not clear whether the results are due to effects of culture, age, or differences in the educational level of the subjects.

The limitation of the studies performed to date is that the effects of culture and education are not separated. Therefore, the purpose of this research was to analyse the influence of each one of these variables (culture and education) while administering a neuropsychological test to an indigenous population.

METHOD

Subjects

The total sample included 44 individuals: 22 were indigenous and 22 were controls, with an average age of 50.98 years (range 16 to 73 years) and average schooling of 20 months (range 0 years to 4 years). As it has been demonstrated that learning how to read and write influences the functional organization of cognitive processes, the sample was divided into four groups: (1) 7 illiterate indigenous subjects; (2) 7 control subjects with no education; (3) 15 indigenous subjects with 1–4 years of education; and (4) 15 control individuals with 1–4 years of education. The individuals were paired by age and educational level. The descriptive characteristics of the sample are shown in Table 1.

The indigenous population under study lives in the state of Yucatan in the Mexican Republic. The Mayan language is spoken by 800,291 people (INEGI, 2000), and they are the majority population in the state of Yucatan. Yucatan is the state with more indigenous language speakers than anywhere else in Mexico. Mayan is part of the Maya-Totonaco group; this language is spoken by peninsular indigenous and by a great number of *mestizos* or persons of mixed race, who use it as an interaction element in their social relationships. Women use the Mayan language more than men, and the new generations speak Spanish more often than Mayan, since Mayan is used only at home (INI, 2002). The traditional Mayan houses have walls made of interwoven branches, with guano, palm leaves, or hay, on top of a soil base. The furnishings are very simple; they generally consist of wooden chairs with leather seats, tree trunk benches, a table, hammocks made of *henequen* or cotton thread. The social organization of the Maya is made up of municipal authorities that, together with the *nojoch tata*, the (holy) *escribientes* or clerks, and the *rezadores*, or people who pray, administer justice and solve the problems of the community.

The control population was selected from Mexico City; this population was made up of individuals born in the city, who did not speak any indigenous language, and who are merchants, work at different trades, or are domestic employees. The subjects of this population were monolingual in Spanish.

TABLE 1
Descriptive characteristics of the sample

				Sex		
	n	*Age in years (SD)*	*Range of age in years*	*M*	*F*	*Level of education in months (SD)*
Indigenous illiterates	7	58.43 (8.88)	16–73	5	2	0 (0.00)
Control illiterates	7	57.71 (9.06)	43–69	2	5	0 (0.00)
Indigenous 1–4	15	47.73 (17.85)	16–73	8	7	30.40 (11.88)
Controls 1–4	15	47.60 (17.85)	16–73	7	8	30.40 (13.50)
Total	44	50.98 (15.94)	16–73	22	22	20.77 (17.56)

Instruments

The following battery was administered for the assessment of the subjects.

1. *Clinical history*. A neurologic and psychiatric screening questionnaire was used to rule out previous neurological and psychiatric conditions, such as brain injury, cerebrovascular disease, epilepsy, Parkinson's disease, psychiatric hospitalizations, etc.

2. *Guide for the Exploration, Comprehension and Expression of Basic Spanish (Ostrosky-Solis, 2002)*. This was applied in order to select subjects who were completely bilingual with an adequate comprehension and expression of Spanish. A score of 70 and above is equivalent to completely bilingual (Maya-Spanish).

3. *The NEUROPSI*. This neuropsychological test battery is a brief battery developed and standardized in Mexico (Ostrosky-Solís et al., 1997; 1999).

The NEUROPSI test battery

This battery includes the following sections.

1. Orientation. Time (day, month, and year), Place (city and specific place), and Person (how old are you?). Max score = 6 pts.

2. Attention and concentration. Max score = 27pts.

2.1. Digits backward, up to six digits. Max score = 6 pts.

2.2. Visual detection. On a sheet that includes 16 different figures, each one repeated 16 times, the subjects are requested to cross out those figures equal to the one presented as a model. The 16 matching figures are equally distributed at the right and the left visual fields. The test is suspended after 1 minute. Two scores are obtained: number of correct responses (max score = 16), and number of errors.

2.3. 20 minus 3, five consecutive times. Max score = 5.

3. Coding. Max score = 18.

3.1. Verbal memory. Six common nouns corresponding to three different semantic categories (animals, fruits, and body parts) are presented three times. After each presentation, the subject repeats those words that he or she remembers. The score is the average number of words repeated in the three trials (max score = 6). In addition, intrusions, perseverations, and recency and primacy effects are noted.

3.2. Copy of a semi-complex figure. A figure similar to the Rey-Osterrieth Complex Figure, but simpler, is presented to the subject. The subject is instructed to copy the figure as best they can. A special scoring system is used, with a max score of 12 pts.

4. Language. Max score = 26.

4.1. Naming. Eight different line drawing figures are presented for naming. They correspond to animals, musical instruments, body parts, and objects. If the subject presents with visual difficulties, an alternative procedure is used: the patient is required to name small objects placed in the hand, and body parts. Max score = 8.

4.2. Repetition. The subject is asked to repeat one monosyllabic word, one three-syllabic word, one phrase with three words, and one seven-word sentence. Successful repetition in each one is scored 1. Max score = 4.

4.3. Comprehension. On a sheet of paper two circles (small and large) and two squares (small and large) are drawn. Six consecutive commands, similar to those used in the Token Test, are given to the subject. The easiest one is "point to the small square," and the hardest one is "in addition to the circles, point to the small square." Max score = 6.

4.4. Semantic verbal fluency (animals). Two scoring systems were used: (a) the total number of correct words, and (b) a 4-point scale. One point was given for 0–5 words; two points to 6–8 words; three points to 9–14 words; and four points to 15 or more words in a minute. Intrusions and perseverations were noted.

4.5. Phonological verbal fluency (words beginning with the letter F). Two scoring systems were used: (a) the total number of correct words, and (b) a 4-point scale. One point was given to 0–3 words; two points to 4–6 words; three points to 7–9 words; and four points to 10 or more words in a minute.Intrusions and perseverations were noted.

5. Reading. The subject is asked to read aloud a short paragraph (109 words). Three questions about the paragraph are presented. Max score = 3.

6. Writing. To write a six-word sentence under dictation; and to copy a different six-word sentence. Max score = 2.

7. Conceptual functions. Max score = 10.

7.1. Similarities. Three pairs of words (e.g., orange–pear) are presented to find the similarity. An example is provided. Each one is scored as 0 (physical similarity: both are round), 1 (functional similarity: both can be eaten), or 2 (the answer corresponds to the supraordinate word: fruits). Max score = 6.

7.2. Calculation abilities. Three simple arithmetical problems are presented. Max score = 3.

7.3. Sequences. The subject is asked to continue a sequence of figures drawn on a sheet of paper (what figure continues?). Max score = 1.

8. Motor functions. Max score = 8.

8.1. Changing the position of the hand. To repeat three positions with the hand (right and left). The model is presented up to three times by the examiner. A max score of 2 is used for the left and for the right hand. Max score = 4.

8.2. Alternating the movements of the hands. To alternate the position of the hands (right hand close, left hand open, and to switch). Max score = 2.

8.3. Opposite reactions. If the examiner shows a finger, the subject must show a fist; if the examiner shows a fist, the subject must show a finger. Max score = 2.

9. Delay recall. Max score = 30.

9.1. Recall of verbal information: (a) spontaneous recall; max score = 6; (b) cueing recall—recall by categories (animals, fruits, and body parts); max score = 6; (c) recognition—the examiner reads 14 different words, and the subject must tell which ones were previously presented; max score = 6.

9.2. Recall of the semi-complex figure. Max score = 12.

In total, 26 different scores are obtained. Maximum total score is 130. Administration time is 25 to 30 minutes. Normative scores were obtained in a 1640-subject sample, corresponding to four age ranges (16–30, 31–50, 51–65, and 66–85 years) and four educational levels (illiterates, 1–4, 5–9, and more than 10 years of formal education) (Ostrosky-Solís et al., 1999). The NEUROPSI manual distinguishes four levels of performance by age and by educational level: normal (within 1 *SD*), mildly abnormal (between 1 and 2 *SD*s), moderately abnormal (between 2 and 3 *SD*s), and severely abnormal (over 3 *SD*s with regard to the mean scores in that age and education group). Subjects were compared with the norms corresponding to their educational level (illiterates or 1–4 years of formal education). The NEUROPSI is sensible to cognitive alterations associated with several clinical groups. An index of 83.53% of sensitivity and 82.07% of specificity has been reported in patients with mild and moderate dementia (Mejia, Gutierrez, & Ostrosky-Solís, in press; Ostrosky-Solís et al., 1997).

Procedure

Inclusion criteria were scoring above 70 in the Guide for Understanding and Expression of Basic Spanish. Individuals with mental illness and/or craniocephalic trauma were discarded. The subjects had to be functionally independent, without history of neurological and psychiatric conditions such as brain injury, cerebrovascular disease, epilepsy, Parkinson's disease, psychiatric hospitalizations, etc.

The participation of the subjects was voluntary; what the assessment involved was explained, and they gave their verbal consent. The administration of the instruments was done individually in a place chosen by the subjects, where they felt at ease (i.e., in their house, in the shade of a tree; noisy places were avoided).

Statistical analysis

Descriptive statistics were obtained for each of the neuropsychological variables per group. An analysis with a T-test for related groups and a T-test for independent groups was used to compare the effects of education and culture independently. The groups were compared in the statistical analysis as follows: (1) indigenous subjects with no education against control subjects with no education; (2) indigenous subjects with 1–4 years of education against control subjects with the same education; (3) the T-test was used to analyse the effect of education in independent groups of indigenous subjects with no education against indigenous subjects with 1–4 years of education; and finally (4) illiterate control subjects were compared to control subjects with 1–4 years of education. The significance level was established at $p < .05$ for all the statistical analyses.

RESULTS

The effects of the culture, Maya vs. control, mantaining the level of education, can be observed in Tables 2 and 3. Table 2 shows the mean, standard deviation, and significance level obtained in the NEUROPSI subtests for illiterate groups (control and indigenous). Significant differences were found only in 2 of the 21 subtests. The differences were found in copy of the semi-complex figure and delayed verbal memory. The indigenous subjects scored higher

TABLE 2
Mean, standard deviation and significance level obtained in the NEUROPSI subtests for illiterate groups (control and indigenous)[a]

Subtest	*Indigenous illiterates N=7 (±SD)*	*Control illiterates N=7 (±SD)*	*t*	*p*
Orientation time	2.86±0.38	2.43±0.79	1.441	.200
Orientation space	2.00±0.00	1.86±0.38	1.000	.356
Orientation person	1.00±0.00	1.00±0.00	–	–
Digit backwards	1.43±1.40	1.57±1.13	−0.225	.829
Visual detection	6.43±3.15	9.17±4.75	−1.656	.149
20 minus 3	1.29±2.21	1.57±2.07	−0.203	.846
Immediate verbal memory	2.86±1.35	4.29±0.76	−2.085	.082
Copy of semi-complex figure	*8.35±0.90*	*6.21±1.41*	*3.198*	*.019*
Naming	7.71±0.49	7.57±0.79	3.540	.736
Repetition	3.43±0.53	3.86±0.38	−2.121	.078
Comprehension	4.14±0.69	4.14±1.57	0.000	1.000
Semantic fluency	11.00±2.58	12.00±2.45	−0.536	.611
Similarities	3.57±1.90	1.86±1.68	1.816	.119
Hand position	1.71±0.49	1.00±1.00	1.698	.140
Alternating movements	0.71±0.76	0.57±0.53	0.420	.689
Opposite reactions	1.43±0.79	1.29±0.76	0.548	.604
Delayed visuospatial memory	6.78±1.34	4.14±2.15	2.334	.058
Delayed verbal memory	*0.14±0.38*	*2.57±1.90*	*−3.232*	*.018*
Cue recall	1.43±1.40	2.29±1.80	−1.072	.325
Recognition recall	5.57±0.53	5.86±0.38	−1.549	.172
NEUROPSI total	64.71±3.21	66.07±4.77	−0.894	.406

[a]Significant differences were found only in 2 of the 21 subtests: copy of the semi-complex figure and delayed verbal memory. The indigenous subjects scored higher in copying; however, in delayed verbal memory they scored lower.

TABLE 3
Mean, standard deviation, and significance level obtained in the NEUROPSI subtests for subjects with 1–4 years of education (control and indigenous)[a]

Subtest	*Indigenous 1–4 N=15 (±SD)*	*Controls 1–4 N=15 (±SD)*	*t*	*p*
Orientation time	2.93±0.26	2.87±0.35	0.564	.582
Orientation space	2.00±0.00	1.87±0.35	1.468	.164
Orientation person	0.87±0.35	1.00±0.00	−1.468	.164
Digit backwards	2.67±0.90	3.00±0.65	−1.160	.265
Visual detection	11.50±4.31	11.50±4.75	0.000	1.000
20 minus 3	3.36±2.34	4.00±1.57	−1.662	.120
Immediate verbal memory	*4.00±0.85*	*4.53±0.99*	*−2.256*	*.041*
Copy of semi-complex figure	9.66±1.69	10.10±1.54	−0.958	.354
Naming	7.80±0.41	7.67±0.62	0.695	.499
Repetition	3.80±0.41	3.93±0.26	−1.000	.334
Comprehension	4.80±0.86	4.60±0.99	0.899	.384
Semantic fluency	*12.73±3.33*	*18.13±4.69*	*−3.965*	*.001*
Phonological fluency	4.88±5.11	6.38±3.46	−0.846	.425
Similarities	3.64±1.78	3.79±2.12	−0.219	.830
Hand position	2.40±1.40	2.53±0.99	−0.299	.769
Alternating movements	0.80±0.86	0.80±0.68	0.000	1.000
Opposite reactions	1.67±0.62	1.60±0.51	0.367	.719
Delayed visuospatial memory	8.53±2.44	8.46±1.96	0.095	.926
Delayed verbal memory	2.67±1.99	2.33±2.41	0.523	.609
Cue recall	3.33±2.06	3.27±1.91	0.113	.912
Recognition recall	5.40±1.12	5.00±1.69	1.146	.271
NEUROPSI total	*84.10±12.65*	*88.26±15.61*	*−3.450*	*.004*

[a]The indigenous subjects obtained significantly lower scores on immediate verbal memory, semantic fluency, and in the NEUROPSI total score.

TABLE 4

Effects of education on the cognitive profile of the Mayan indigenous subjects: Mean, standard deviation, and significance level obtained in the NEUROPSI subtests for illiterate indigenous subjects and indigenous subjects with 1–4 years of education[a]

Subtest	*Indigenous illiterates n=7 (±SD)*	*Indigenous 1–4 n=15 (±SD)*	*t*	*p*
Orientation time	2.86±0.38	2.93±0.26	−0.483	.641
Orientation space	2.00±0.00	2.00±0.00	–	–
Orientation person	1.00±0.00	0.87±0.35	1.468	.164
Digit backwards	1.43±1.40	2.67±0.90	−2.146	.063
Visual detection	*6.43±3.15*	*11.50±4.31*	*−3.094*	*.007*
20 minus 3	1.29±2.21	3.36±2.34	−2.127	.055
Immediate verbal memory	2.86±1.35	4.00±0.85	−2.066	.071
Copy of semi-complex figure	*8.35±0.90*	*9.66±1.69*	*−2.361*	*.029*
Naming	7.71±0.49	7.80±0.41	−0.402	.696
Repetition	3.43±0.53	3.80±0.41	−1.625	.137
Comprehension	4.14±0.69	4.80±0.86	−1.917	.075
Semantic fluency	11.00±2.58	12.73±3.33	−1.333	.202
Similarities	3.57±1.90	3.64±1.78	−0.083	.935
Hand position	1.71±0.49	2.40±1.40	−1.686	.108
Alternating movements	0.71±0.76	0.80±0.86	−0.237	.816
Opposite reactions	1.43±0.79	1.67±0.62	−0.706	.497
Delayed visuospatial memory	*6.78±1.34*	*8.53±2.44*	*−2.111*	*.049*
Delayed verbal memory	*0.14±0.38*	*2.67±1.99*	*−4.737*	*.000*
Cue recall	*1.43±1.40*	*3.33±2.06*	*−2.542*	*.021*
Recognition recall	5.57±0.53	5.40±1.12	0.486	.633
NEUROPSI total	*64.71±3.21*	*84.10±12.66*	*−5.561*	*.000*

[a]The group with 1–4 years of education obtained higher scores on visual detection, copy and delayed recall of the semi-complex figure, delayed verbal memory in spontaneous and cued recall, and on the total NEUROPSI score.

TABLE 5

Effects of education on the cognitive profile of the control subjects: Mean, standard deviation, and significance level obtained in the NEUROPSI subtests for illiterate control subjects and control subjects with 1–4 years of education[a]

Subtest	*Control illiterates N=7 (±SD)*	*Controls 1–4 n=15 (±SD)*	*t*	*p*
Orientation time	2.43±0.79	2.87±0.35	−1.409	.201
Orientation space	1.86±0.38	1.87±0.35	−0.506	.956
Orientation person	1.00±0.00	1.00±0.00	–	–
Digit backwards	*1.57±1.13*	*3.00±0.65*	*−3.101*	*.015*
Visual detection	9.17±4.75	11.50±4.75	−0.812	.433
20 minus 3	*1.57±2.07*	*4.00±1.57*	*−2.736*	*.022*
Immediate verbal memory	4.29 ± 0.76	4.53±0.99	−0.646	.528
Copy of semi-complex figure	*6.21±1.41*	*10.10±1.54*	*−5.831*	*.000*
Naming	7.57±0.79	7.67±0.62	−0.282	.784
Repetition	3.86±0.38	3.93±0.26	−0.483	.641
Comprehension	4.14±1.57	4.60±0.99	−0.707	.499
Semantic fluency	*12.00±2.45*	*18.13±4.69*	*−4.025*	*.001*
Similarities	*1.86±1.68*	*3.79±2.12*	*−2.357*	*.033*
Hand position	*1.00±1.00*	*2.53±0.99*	*−3.360*	*.006*
Alternating movements	0.57±0.53	0.80±0.68	−0.856	.406
Opposite reactions	1.29±0.76	1.60±0.51	−1.000	.345
Delayed visuospatial memory	*4.14±2.15*	*8.46±1.96*	*−4.423*	*.001*
Delayed verbal memory	2.57±1.90	2.33±2.41	0.250	.806
Cue recall	2.29±1.80	3.27±1.91	−1.168	.265
Recognition recall	5.86±0.38	5.00±1.69	1.867	.080
NEUROPSI total	*66.07±4.77*	*88.26±15.61*	*−5.024*	*.000*

[a]Significant differences in favour of subjects with 1–4 years of education were present in digit backwards, consecutive subtraction (20−3), copy and delay recall of semi-complex figure, semantic fluency, similarities, hand position, and in the total NEUROPSI score.

in copying; however, they scored lower in delayed verbal memory.

Table 3 shows the neuropsychological subtests that turned out to be significantly different in indigenous and in controls with 1–4 years of education. The indigenous subjects obtained significant lower scores in immediate verbal memory, semantic fluency, and in the total NEUROPSI score.

Tables 4 and 5 shows the effect of education on the cognitive profile of the illiterate subjects once they acquired reading and writing skills. Table 4 shows the neuropsychological profile of the indigenous population with no education against the indigenous population with 1–4 years of education. The group with 1–4 years of education obtained higher scores on visual detection, copy and delayed recall of a semi-complex figure, delayed verbal memory in spontaneous and cue recall, and in the total NEUROPSI score.

Table 5 shows comparative data of the illiterate control subjects vs. the control subjects with 1–4 years of education. Significant differences in favour of subjects with 1–4 years of education

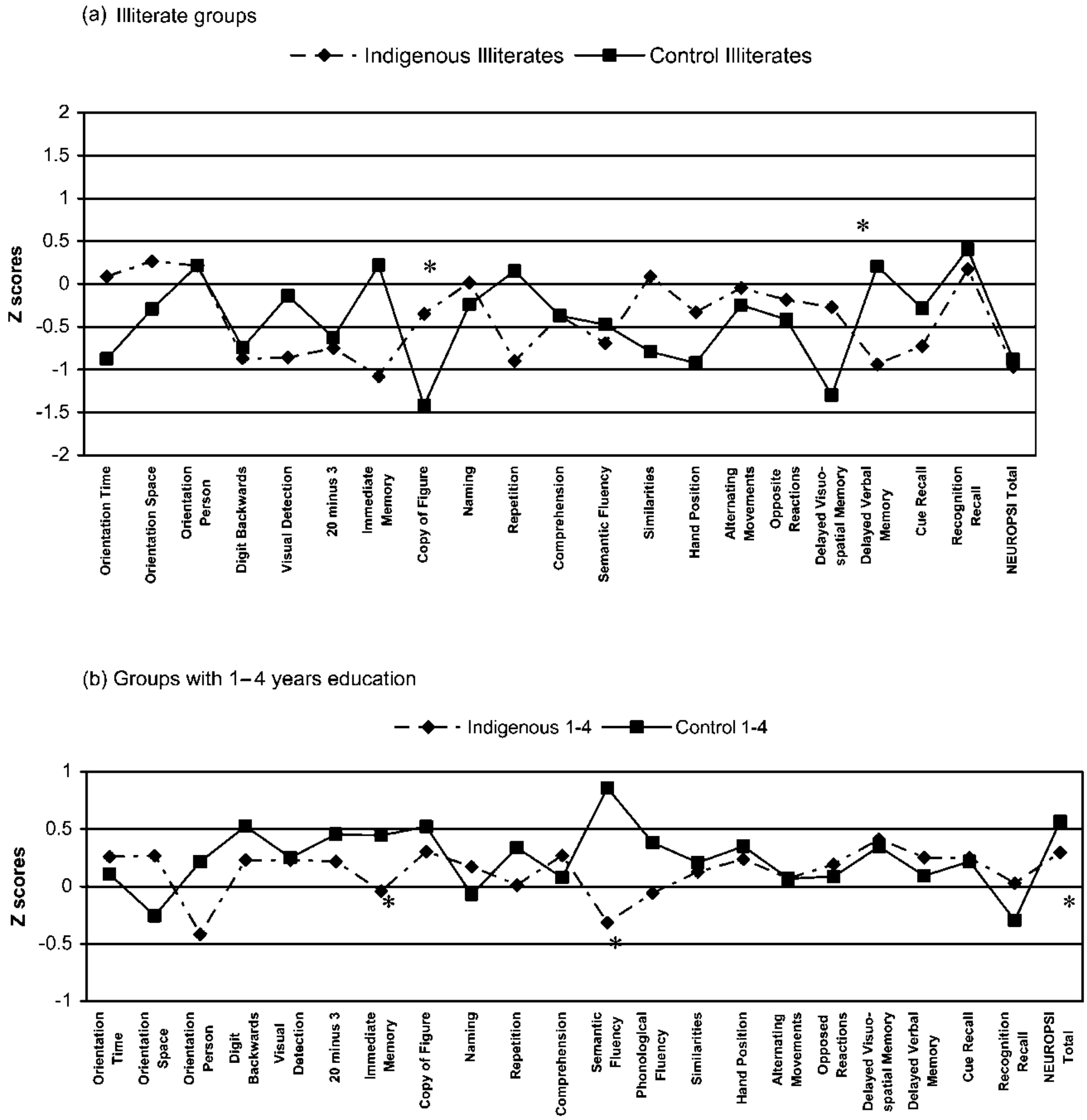

Figure 1. Effect of the culture, Maya vs. control, maintaining the level of education. 1(a) shows the neuropsychological profile of the illiterate groups. Significant differences were found in copy of the semi-complex figure and delayed verbal memory. The indigenous subjects scored higher in copying; however, in delayed verbal memory they scored lower. 1(b) shows the neuropsychological profile of subjects with 1–4 years of education. The indigenous subjects obtained significant lower scores in immediate verbal memory, semantic fluency, and in the NEUROPSI total score.

were present in the eight subtests: digit backwards, consecutive subtraction (20−3), copy and delayed recall of the semi-complex figure, semantic fluency, similarities, hand position, and in the total NEUROPSI score.

Figure 1 shows the effect of culture, Maya vs. controls, in the illiterates and in those with 1–4 years of education. Figure 2 shows the effect of education on the cognitive profile of the illiterate subjects (in both the Maya and the control group) once they acquired reading and writing skills.

DISCUSSION

Examining the influence of the cultural factor, the results obtained in this research indicate that illiterate indigenous subjects showed better execution in visuoperceptual tasks (copy of semi-complex figure), but obtained lower scores on subtests related to delayed verbal memory. These results suggest that the cultural environment in which the indigenous people live has a significant influence on their cognitive organization and,

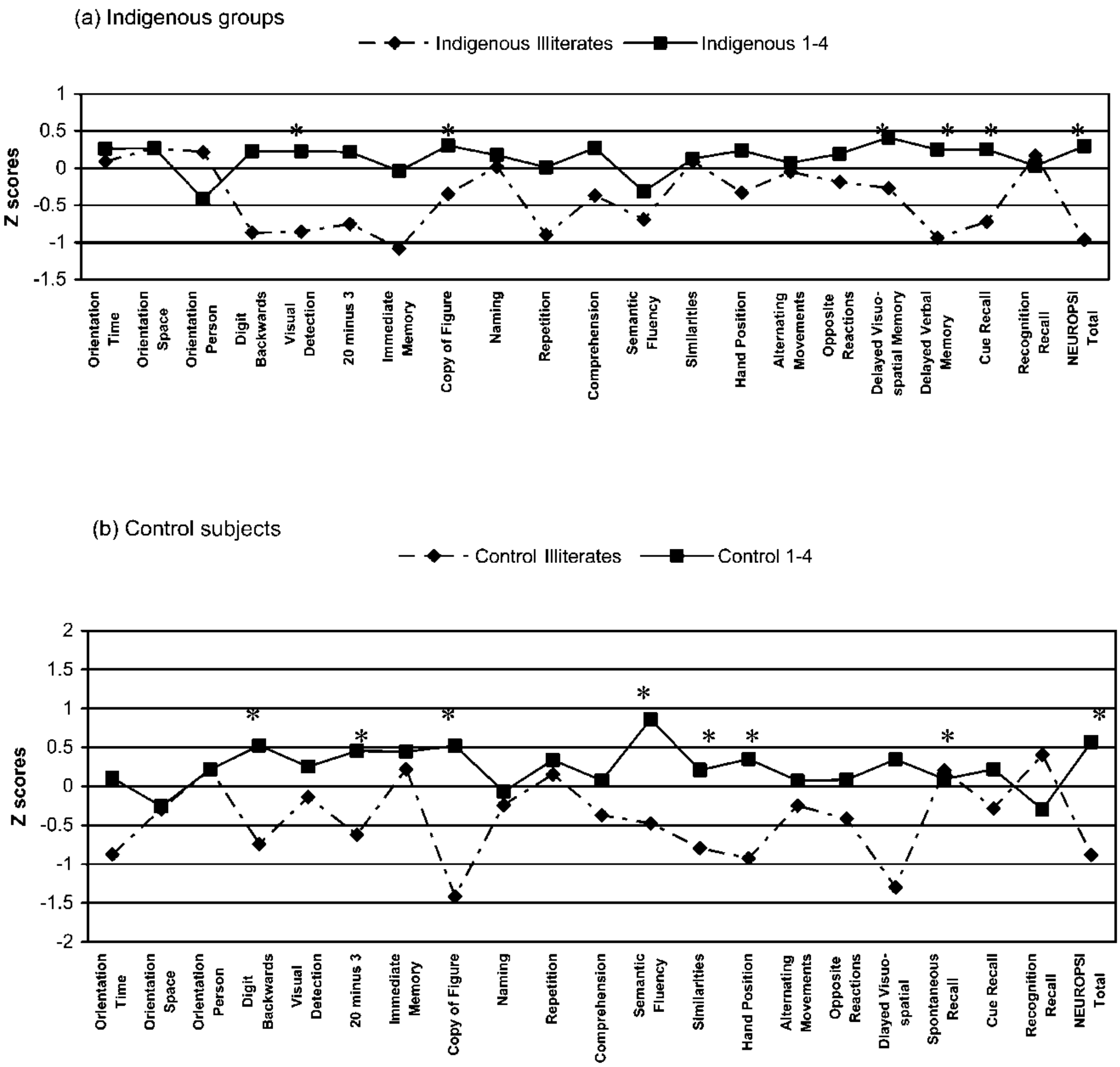

Figure 2. Effect of education on the cognitive profile of the illiterate subjects (in both the Maya and the control group) once they acquired reading and writing skills. 2(a) shows the neuropsychological profile of the indigenous population with no education against the indigenous population with 1–4 years of education. The group with 1–4 years of education obtained higher scores on visual detection, copy and delayed recall of the semi-complex figure, delayed verbal memory in spontaneous and cued recall, and in the total NEUROPSI score. 2(b) shows comparative data of the illiterate control subjects vs. the control subjects with 1–4 years of education. Significant differences in favour of subjects with 1–4 years of education were present in the eight subtests: digit backwards, consecutive subtraction (20−3), copy and delayed recall of the semi-complex figure, semantic fluency, similarities, hand position, and in the total NEUROPSI score.

therefore, on the expression of their skills. Their culture demands the use of visuospatial skills, since they are people devoted to farming and basketry manufacturing for economic survival. Nevertheless, delayed verbal memory skills are probably not used constantly or demanded in their environment. On the contrary, control subjects who live in the city probably require more verbal memory skills more than visuospatial skills, and therefore showed significantly higher scores.

These results concur with Ardila and Moreno (2001) who, in their study on Arauco indigenous people devoted to fishing and hunting, found good execution of ideomotor skills; however, the opposite result was found when copying figures. Although they reported poor performance, in this study we found that the performance of indigenous subjects was above that of the control subjects. Probably these differences are due to the dissimilar demands of the environment.

Although they had the same level of education (1–4 years), when we compared indigenous subjects with controls we found significant difficulties in delayed verbal memory, semantic fluency, and total NEUROPSI. This leads us to believe that although both groups have acquired reading and writing, culture still exerts influence on the use of different skills, such as delayed verbal memory and semantic fluency. These differences could also be due to the fact that the indigenous subjects were bilinguals (Maya-Spanish) and, although fluent in Spanish, the use of both languages might interfere with their semantic fluency performance. Differences also might be due to the fact that in their day-to-day functioning, illiterate subjects do no have to use delayed verbal memory skills as much as the control group. Not only does culture intervene in the development and use of cognitive processes, but education also influences the appearance of certain cognitive skills. It has been said that education is not limited to the acquisition of reading, writing, and calculus; it also requires the knowledge of the practical use and adaptation of such skills to the context and situation where they are required (Manly et al., 1999; Morais, Kolinsky, Alegria, & Scliar-Cabral, 1998). Learning the use of skills acquired during the literacy process is a challenge for any individual, which also makes possible the necessary modifications and adjustments in order to perform adequately the tasks of the neuropsychological assessment.

In order to determine the influence of education on the cognitive profile of both groups of subjects (indigenous and controls) once they acquired reading and writing skills, we compare the neuropsychological profile of illiterate vs. those educated for 1–4 years. We found significant differences, in favour of the subjects with 1 to 4 years of schooling, in attention and visuoperceptual processing (visual detection, copy of a figure), visual and verbal memory (delayed recall of complex figure, verbal memory), and the NEUROPSI total score; these data show that even if it is true that culture influences the application and development of certain (visuospatial) skills, education influences it too. Results lead us to suppose that education drives the acquisition of specific skills such as attention and memory abilities.

The former data agree with several investigators who have found lower performance in illiterates in memory tasks, visuospatial skills, and digit retention (Ardila et al., 1989, 2000; Castro-Caldas & Reis, 2000; Ostrosky-Solís et al., 1999, 1998; Rosselliet al., 1990). As Morais and Kolinsky (2000) pointed out, the written language and its inherent characteristics have deep consequences for the ability to process linguistic and non-linguistic information. For example, the linguistic domain affects phonological and lexical knowledge; semantics influences the ability to categorize and conceptual representation as well as the strategies used for codification and recall during memory; and executive functions are expressed in selective attention and in the inhibition of inappropriate responses. Likewise, education provides training and improves the ability to process information from concrete stimulus to a model of abstract representation of the real world. Those skills acquired at school are essential to perform the operations required for the execution of neuropsychological tests (Grossi et al., 1993). Thus, once reading and writing are acquired, we observe a significant change in the way stimuli are memorized and conceptualized.

Our data show that culture can influence different skills; although both groups were illiterates, the Maya group performed better on visuospatial tasks whereas the control group scored higher on delayed verbal memory. Education trains working memory as well as strategies to improve both visual and verbal delayed memory. No significant differences were found in other cognitive processes (orientation, comprehension, and some executive functions). Our data show that culture dictates what it is important for our survival, and that education could be considered as a subculture that emphasizes the development of certain skills instead of others; however, the influences of both variables on cognitive skills are different, so both should be considered when assessing subjects from different cultures. The interpretation of neuropsychological tests, and thus accurate assessment of cognitive dysfunction, is dependent on both education and cultural skills.

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