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Neuropsychological Test Performance in Illiterate Subjects

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The purpose of this study was to further analyze the effects of education across different age ranges on neuropsychological test performance. Two different analyses were performed. The first analysis was conducted in order to pinpoint the impact of school attendance on neuropsychological testing. A group of 64 illiterate normal subjects was selected in the Mexican Republic. Their performance was compared with two barely schooled control groups (1–2 and 3–4 years of schooling). The subjects' ages ranged from 16 to 85 years. In the second analysis, the illiterate subjects were further matched by age and sex with individuals with 1 to 4, 5 to 9, and 10 to 19 years of formal education. The Spanish version of the NEUROPSI neuropsychological test battery (Ostrosky, Ardila, & Rosselli, 1997) was used. Results indicated a significant educational effect on most of the tests. Largest educational effect was noted in constructional abilities (copying of a figure), language (comprehension), phonological verbal fluency, and conceptual functions (similarities, calculation abilities, and sequences). Aging effect was noted in visuoperceptual (visual detection) and memory scores. In the first subject sample, it was evident that, despite using such limited educational range (from 0–4 years of formal education), and such a wide age range (from 16–85 years), schooling represented a stronger variable than age. It is proposed that education effect on neuropsychological test performance represents a negatively accelerated curve, tending to a plateau. © 1998 National Academy of Neuropsychology. Published by Elsevier Science Ltd

A nonneglectable proportion of the world population (about one third of the world's population) is illiterate (Unicef, 1995). Writing only goes back some 5,000 to 6,000 years in human

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history, and just a few centuries ago, reading and writing abilities were uncommon among the general population. It might be assumed that the acquisition of reading and writing skills may have changed the brain organization of cognitive activity in general.

It is evident that literacy may be reflected in the performance of those tasks used not only in psychological, but also neuropsychological evaluation. Very important cognitive consequences of learning to read and to write have been suggested, for example, changes in visual perception, logical reasoning, and remembering strategies (Laboratory of Comparative Human Cognition, 1983). Even the influence of schooling on formal operational thinking has been pointed out (Laurendeau-Bendavid, 1977). The analysis of illiteracy can help, in consequence, not only to discern the influence of educational background on neuropsychological test performance, but also may contribute to a better understanding of the cerebral organization of cognitive activity.

Educational level represents a crucial variable in psychological test performance. Educational attainment significantly correlates with scores on standard tests of intelligence. This correlation ranges from about 0.57 to 0.75 (Matarazzo, 1979). Correlations with verbal intelligence subtests are usually higher (from about 0.66 to 0.75) than correlations with performance intelligence subtests (from about 0.57 to 0.61). Therefore, it can be assumed that psychometric measures of intelligence are strongly biased by our current schooling system.

Several studies have proved a similarly strong association between educational level and performance on various neuropsychological measures (e.g., Ardila, Rosselli, & Ostrosky, 1992; Ardila, Rosselli, & Puente, 1994; Ardila, Rosselli, & Rosas, 1989; Bornstein & Suga, 1988; Finlayson, Johnson, & Reitan, 1977; Heaton, Grant, & Mathews, 1986; Leckliter & Matarazzo, 1989; Lecours et al., 1987a, 1987b, 1988; Ostrosky, Canseco, Quintanar, Navarro, & Ardila, 1985; Ostrosky et al., 1986; Rosselli, Ardila, & Rosas, 1990). In general, some tests have been observed to be much more sensitive to educational variables (e.g., language tests) than others (e.g., the Wisconsin Card Sorting Test; Rosselli, 1993).

Cornelious and Caspi (1987) found that educational level has a substantial relationship with performance on verbal meaning tests but was not systematically related to everyday problem-solving (i.e., functional criterion of intelligence). Craik, Byrd, and Swanson (1987) observed that differences in memory loss during aging is related to socioeconomic status. Ardila and Rosselli (1989) reported that during normal aging, educational variable was even more influential on neuropsychological performance than age variable. Albert and Heaton (1988) argued that when education is controlled, there is no longer evidence of an age-related decline in verbal intelligence.

The significance of schooling on neuropsychological test performance has been reported for quite diverse types of abilities, including, but not limited to, memory, language, problem-solving, constructional abilities, motor skills, and calculation abilities (e.g., Ardila, Rosselli, & Rosas, 1989; Rosselli et al., 1990; Lecours et al., 1987a, 1987b, 1988). Without careful consideration of the educational variables, neuropsychology runs the risk of finding brain pathology where there are only educational differences. To illustrate this point, Bertolucci, Brucki, Campacci, and Julian (1994) selected a 530-subject sample of individuals with diverse educational background. They noted that not only does educational level represent an extremely significant predictor in the Mini-Mental State Exam (Folstein, Folstein, & McHugh, 1975) scores, but also that the cut-off point for illiteracy should be set in only 13 points out of 30. This 13-point score is usually considered as significantly abnormal for any educated subject (Lezak, 1995).

This research was directed to further analyze the effects of educational variable on neuropsychological tests performance. Two different types of analysis were performed. (a) A group of 64 illiterate (0 years of schooling) normal subjects was selected (25 males, 39 females). Their performance was compared with two barely schooled control groups (1–2 and 2–3

TABLE 1
Distribution of the First Sample

Education	Age (Years) 16–30	31–50	51–65	66–85	Total
Illiterate	16	16	16	16	64
1–2 years	16	16	16	16	64
3–4 years	16	16	16	16	64
Total	48	48	48	48	192

years of schooling) in order to analyze the impact of any school attendance on neuropsychological test performance. Interactions with age variable were specially analyzed. Total sample was 192 subjects (64 × 3). Table 1 presents the distribution of this first sample. (b) The 64 subjects in the illiterate group were further matched by age and sex with individuals with 1 to 4, 5 to 9, and 10 to 19 years of education. Total sample in the second analysis was 256 subjects (64 × 4). The purpose of this second analysis was to pinpoint the educational effect on neuropsychological test performance across different educational level ranges.

METHOD

Subjects

Two different samples of illiterate subjects were selected. The first sample was selected during the standardization and normalization study of the NEUROPSI neuropsychological test battery (Ostrosky, Ardila, & Rosselli, 1997, submitted). Twenty-seven illiterate subjects were recruited in Mexico City during this normalization study. The rest of the illiterate subjects were collected in Colima City, Mexico. All schooled subjects were selected in Mexico City.

Three criteria for inclusion in the illiterate sample were used: (a) Zero school attendance, as a result of economical restrictions, and/or long distances between home and school during childhood; (b) inability to write their own name, for this purpose, all the subjects were requested to write their names; only those subjects unable to do it were included in the illiterate sample; and (c) normal performance in daily life activities (i.e., normal functional intelligence) according to the subject's sociocultural environment.

A neurologic and psychiatric screening questionnaire was used to rule out previous neurologic and psychiatric conditions, such as brain injury, cerebrovascular disease, epilepsy, Parkinson's disease, psychiatric hospitalizations, etc. A handedness questionnaire was also presented. Further, the NEUROPSI neuropsychological test battery was individually administered. All the subjects were nonpaid volunteers. All participants included in both the experimental and control groups were active and functionally independent. Testing was administered by graduate neuropsychology students.

Instrument

The Spanish version of the NEUROPSI neuropsychological test battery (Ostrosky, Ardila, & Rosselli, 1997) was individually administered. It includes the following sections:

1. Orientation. Time (day, month, and year), Space (city and specific place), and Person (how old are you? or, When were you born). Maximum score = 6 points.
2. Attention and concentration (Maximum score = 27).

2.1. Digits backwards, up to six digits. Maximum score = 6 points.
2.2. Visual detection. In 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 at the left visual fields. The test is suspended after 1 minute. Two scores are obtained: number of correct responses (maximum score = 16), and number of errors.
2.3. 20 − 3, five consecutive times. Maximum score = 5).

3. Coding (Maximum 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 (maximum score = 6). In addition, intrusions, perseverations, 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 to his or her best ability. A special scoring system is used, with a maximum score of 12 points.

4. Language (Maximum score = 26).
4.1. Naming. Eight different line drawing figures are presented to be named. They correspond to animals, musical instruments, body parts, and objects. If the subject presents visual difficulties, an alternative procedure is used: The patient is required to name small objects placed in the hand, and body parts. Maximum 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. Maximum 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 the small square,’’ and the hardest one is ‘‘in addition to the circles, point to the small square.’’ Maximum 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 to 5 words; two points for 6 to 8 words; three points for 9 to 14 words; and four points for 15 or more words in a minute. Intrusions and perseverations are 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 for 0 to 3 words; two points for 4 to 6 words; three points for 7 to 9 words; and four points for 10 or more words in a minute. Intrusions and perseverations are noted.

5. Reading. The subject is asked to read aloud a short paragraph (109 words). Three questions about the paragraph are presented. Maximum score = 3.
6. Writing. To write under dictation a six-word sentence; and to write by copying a different six-word sentence. Maximum score = 2.
7. Conceptual functions (maximum 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). Maximum score = 6.

7.2. Calculation abilities. Three simple arithmetical problems are presented. Maximum score = 3.
7.3. Sequences. The subject is asked to continue a sequence of figures drawn on a paper (what figure continues?). Maximum score = 1.

8. Motor functions (maximum score = 8)
   8.1. hanging the position of the hand. To repeat three positions with the hand (right and left). The model is presented by the examiner up to three times. A maximum score of 2 is used for the left and for the right hand. Maximum 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). Maximum score = 2.
   8.3 Opposite reactions. If the examiner shows the finger, the subject must show the fist; if the examiner shows the fist, the subject must show the finger. Maximum score = 2.
9. Recall (maximum score = 30).
   9.1 Recall of verbal information.
      9.1.1. Spontaneous recall. Maximum recall = 6.
      9.1.2. Cueing recall: Recall by categories (animals, fruits, and body parts). Maximum score = 6.
      9.1.3. Recognition. The examiner reads 14 different words and the subject must tell which ones were previously presented. Maximum score = 6.
   9.2. Recall of the semi-complex figure. Maximum score = 12.

In total, 26 different scores are obtained. Maximum total score is 130. Testing was performed in a single sessions. Reading and writing sections were not used in this research. Administration time was 25 to 30 minutes.

With the purpose of obtaining a test-retest reliability score, the NEUROPSI was administered twice to a group of 30 normal subjects, at a 3-month interval. Interrater reliability was determined by independent scores of the NEUROPSI performance of 20 subjects by two examiners. The test-retest reliability score was 0.89 for the NEUROPSI total score. Reliability measures for each of the NEUROPSI scales ranged from 0.89 (Verbal fluency, Copy and Recall of the semi-complex figure, Verbal memory, Spontaneus recall of verbal information, and Calculation abilities) to 1.0 (Copy of a semi-complex figure, Naming, Repetition, Comprehension, and Orientation). Interrater correlation coefficients for the NEUROPSI scales ranged from 0.93 (Copy and recall of a semi-complex figure) to 1.0 (total NEUROPSI score and all other scales).

RESULTS

Table 2 presents the general results in the neuropsychological test battery found in the first sample. Subjects with a higher educational level outperformed those subjects with a lower educational attendance. Differences between the first (illiterate) and the third educational (3–4 school years) group were observed in all the tests, except Orientation in person. The largest difference was found in the Verbal fluency test—phonological condition. Smallest difference was observed in the Motor functions section—opposite reactions subtest, and Coding—verbal memory.

An analysis of variance (ANOVA) was used to analyze differences among the three educational groups (illiterate, 1–2 of school, and 3–4 years of school). The significance level was set at $p < .05$ after Bonferroni correction. In 13 of the 25 test scores statistically significant differences were found with a better performance in the subjects with a higher educational

TABLE 2
Means (*M*) and Standard Deviations (*SD*) Found in the Different NEUROPSI Neuropsychological Tests According to the School Level in the First Sample ($N = 192$). Differences Among the Groups Are Pointed Out

	Years of School								
	0		1–2		3–4				
Test	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*F*	*p*	Differences Observed
Orientation									
Time	2.3	(0.8)	2.2	(0.9)	2.4	(0.8)	1.33	.266	none
Space	1.9	(0.2)	1.9	(0.2)	2.0	(0.0)	1.63	.197	none
Person	0.9	(0.1)	0.9	(0.2)	0.9	(0.2)	0.78	.455	none
Attention									
Digits forwards	3.9	(1.1)	4.1	(1.0)	4.6	(0.9)	5.70	.004	G3 vs. G1
Digits backwards	2.4	(1.1)	2.6	(0.9)	2.7	(1.1)	1.63	.198	none
Visual detection	9.9	(4.5)	11.2	(4.1)	12.5	(3.2)	6.49	.002	G3 vs. G1
20 − 3	3.1	(1.9)	3.1	(1.7)	4.1	(1.2)	7.49	.001	G3 vs. G1,G2
Coding									
Verbal memory	4.2	(0.6)	4.2	(0.6)	4.3	(0.7)	0.46	.632	none
Copy of a semi-complex figure	7.5	(2.0)	8.8	(2.4)	9.4	(1.9)	16.00	.0001	G3 vs. G1,G2
Language									
Naming	7.3	(0.8)	7.3	(1.1)	7.5	(0.9)	1.35	.261	none
Repetition	3.8	(0.4)	3.9	(0.4)	3.9	(0.5)	0.11	.893	none
Comprehension	3.7	(1.2)	4.4	(0.8)	4.6	(1.0)	15.16	.0001	G1 vs. G2,G3
Verbal fluency									
Semantic	13.5	(4.6)	14.6	(4.9)	15.4	(5.5)	2.56	.079	none
Phonol	3.1	(3.7)	6.5	(4.0)	7.0	(4.1)	18.18	.0001	G1 vs. G2,G3
Conceptual functions									
Similarities	2.1	(2.2)	3.5	(2.1)	3.9	(1.9)	13.36	.0001	G1 vs. G2,G3
Calculation abilities	0.9	(1.0)	1.5	(1.1)	1.6	(1.1)	5.99	.003	G3 vs. G1,G2
Sequences	0.1	(0.3)	0.2	(0.4)	0.4	(0.5)	11.49	.0001	G3 vs. G1,G2
Motor functions									
Changing left-hand position	1.1	(0.7)	1.2	(0.7)	1.3	(0.7)	0.59	.551	none
Changing right-hand position	1.0	(0.7)	1.1	(0.6)	1.2	(0.7)	1.22	.295	none
Alternating movements	0.8	(0.7)	1.1	(0.7)	1.3	(0.7)	6.84	.001	G3 vs. G1
Opposite reactions	1.7	(0.5)	1.7	(0.5)	1.8	(0.4)	1.20	.303	none
Recall									
Words	3.1	(2.2)	2.8	(2.0)	3.8	(2.1)	3.77	.024	G3 vs. G2
Cueing	4.1	(1.4)	4.3	(1.4)	4.7	(1.4)	3.89	.022	G3 vs. G1
Recognition	5.4	(1.1)	5.6	(0.6)	5.6	(0.7)	1.00	.369	none
Semi-complex figure	6.3	(2.2)	7.0	(2.4)	8.4	(2.3)	15.01	.0001	G3 vs. G1,G2

Note. G1 = zero years of school; G2 = 1–4 years of school; G3 = 5–9 years of school.

level. In 12 test scores (Orientation—time, space, and person; Digit backwards, Coding—verbal memory, Language naming, Language repetition, Semantic verbal fluency, Motor function — changing the position of the left and right hand, opposite reactions; and Recall—recognition of words) no statistically significant differences were observed. In three tests (Language comprehension, Phonological verbal fluency, and Conceptual functions—similarities) statistically significant differences between the first and the second education groups were noted. It means, in these three tests, just 1 to 2 years of education made a statistically significant difference in their performance. The strongest significant differences ($p < .0001$) were observed in the Copy of a semi-complex figure, Language comprehension, Phonological verbal fluency, Conceptual functions—similarities, Conceptual functions—sequences, and Recall of a semi-complex figure.

Table 3 presents the general results in the different tests according to the age variable. It was observed that in most tests, scores tended to decrease across the age ranges. Nonetheless, in six tests (Digits backwards, 20 − 3, Naming, Repetition, Calculation abilities, and Changing right-hand position) scores increase between the first (16–30 years) and the fourth (66–85 years) age range.

An ANOVA was used to analyze differences among the four age groups. In nine tests, statistically significant differences were observed: Orientation in time, Visual detection, Verbal memory, Copy of a semi-complex figure, Language naming, Motor functions—opposite reactions; and in three out of four recall subtests (Words, Cuing, Recognition, and Semi-complex figure). Statistically significant differences were mainly observed between the first and the last age ranges.

An ANOVA 3 × 4 was used to analyze the effects of schooling, age, and the interaction of both variables on the different sections of the test battery (Table 4). Educational differences were notoriously more robust than age differences. Interaction between both variables were statistically significant only in three tests: Visual detection, Language repetition, and Conceptual functions—Similarities. For the rest of the tests, the age and education effects were independent.

In order to extend the analysis of the education effects on neuropsychological test performance, the 64 illiterate participants were matched by age and sex with a group of individuals with 1 to 4, 5 to 9, and 10 to 19 years of education. Total sample in this second analysis was 256 subjects. The purpose of this second analysis was to pinpoint the educational effect on neuropsychological test performance across different educational level ranges, from illiteracy to the university educational level.

Table 5 presents the means and standard deviations in the different test for the four educational groups. For all the tests, except Orientation in space, scores increased across educational ranges. Strongest educational effect was observed in the Phonological verbal fluency subtest; scores in the highest educational group were over four times higher than in the illiterate sample.

An ANOVA was used to analyze differences among the four educational groups (Table 6). In all the tests, except Orientation in space, Digits forwards, Opposite reactions, and Recall of words—Recognition condition, statistically significant differences were observed. In seven test scores (Orientation in time, Copy of a semi-complex figure, Comprehension, Phonological verbal fluency, Similarities, Calculation abilities, and Recall of a semi-complex figure), significant differences were observed between the first (illiterate) and the second (1–4 school years) educational groups. Nonetheless, only in two tests (Digits backwards and Phonological verbal fluency) were statistically significant differences found between the third (5–9 school years) and the fourth (10–19 school years) educational groups. That is, educational variable is a more significant variable on subjects with lower educational levels than in subjects with a higher school attendance.

Finally, the percentage of performance with regard to the maximum score for each test in the four educational groups was calculated. These results are presented in Table 7. In some subtests, performance is roughly equivalent across the educational groups: Language repetition, Opposite reactions, and Recall of words—Recognition condition. In other tests, performance in the illiterate group is below half of the performance observed in subjects with the highest educational level: Phonological verbal fluency, Calculation abilities, Sequences, and Alternating movements. Therefore, these tests are extremely sensitive to the educational effects. The rest of the neuropsychological test performances by the illiterate subjects were over 50% of the performances observed in subjects with the highest educational level.

In addition to the test scores analysis, a qualitative analysis of the test performances of the illiterate group was also carried out. Several qualitative differences were observed. For example, the strategy for copying the semi-complex figure was overtly dependent on featural

TABLE 3
Means (*M*) and Standard Deviations (*SD*) Found in the Different NEUROPSI Neuropsychological Tests According to Age in the First Sample ($N = 192$). Differences Among the Groups Are Pointed Out

Test	Age (Years) 16–30 *M*	(*SD*)	31–50 *M*	(*SD*)	51–65 *M*	(*SD*)	66–85 *M*	(*SD*)	*F*	*p*	Differences Observed
Orientation											
Time	1.9	(1.1)	2.6	(0.5)	2.5	(0.5)	2.4	(0.6)	9.36	.0001	G1 vs. G2,G3,G4
Space	1.9	(0.2)	1.9	(0.1)	2.0	(0.0)	1.9	(0.2)	0.80	.493	none
Person	1.0	(0.0)	0.9	(0.2)	0.9	(0.3)	0.9	(0.2)	1.40	.068	none
Attention											
Digits forwards	4.3	(1.0)	4.2	(1.1)	4.3	(1.0)	3.9	(0.7)	0.63	.596	none
Digits backwards	2.4	(1.1)	2.6	(0.9)	2.8	(1.1)	2.6	(0.9)	1.70	.167	none
Visual detection	13.2	(3.4)	11.5	(3.3)	9.7	(4.0)	7.8	(5.2)	11.33	.0001	G1 vs. G3,G4; G2 vs. G4
20 − 3	3.2	(1.7)	3.6	(1.5)	3.5	(1.8)	4.1	(1.5)	1.28	.282	none
Coding											
Verbal memory	4.3	(0.7)	4.5	(0.6)	4.4	(0.5)	3.8	(0.6)	7.01	.002	G3 vs. G1,G2,G3
Copy of a semi-complex figure	9.2	(2.0)	8.7	(2.2)	8.2	(2.2)	7.8	(2.5)	3.58	.014	G1 vs. G4

Language											
Naming	7.2	(1.1)	7.5	(0.7)	7.4	(0.6)	7.5	(1.0)	2.76	.043	G1 vs. G2
Repetition	3.8	(0.4)	3.8	(0.4)	3.9	(0.4)	3.9	(0.4)	0.59	.616	none
Comprehension	4.3	(1.0)	4.4	(1.1)	4.0	(1.2)	4.2	(1.3)	1.28	.281	none
Verbal fluency											
Semantic	14.9	(5.8)	13.6	(4.2)	15.4	(5.4)	14.1	(4.3)	1.30	.274	none
Phonol	5.7	(4.4)	4.9	(3.6)	6.1	(4.8)	5.7	(4.6)	0.61	.605	none
Conceptual functions											
Similarities	3.0	(2.1)	3.7	(2.1)	3.0	(2.2)	2.6	(2.2)	2.29	.079	none
Calculation abilities	1.0	(1.1)	1.4	(1.0)	1.5	(1.1)	1.6	(1.1)	2.59	.054	none
Sequences	0.3	(0.4)	0.2	(0.4)	0.2	(0.4)	0.2	(0.4)	0.74	.525	none
Motor functions											
Changing left-hand position	1.1	(0.8)	1.4	(0.6)	1.2	(0.6)	1.0	(0.8)	2.58	.054	none
Changing right-hand position	1.0	(0.7)	1.1	(0.5)	1.1	(0.8)	1.3	(0.7)	1.37	.252	none
Alternating movements	1.2	(0.7)	1.0	(0.6)	0.9	(0.7)	0.9	(0.8)	1.84	.140	none
Opposite reactions	1.9	(0.3)	1.8	(0.4)	1.8	(0.4)	1.5	(0.6)	5.54	.001	G4 vs. G1,G2,G3
Recall											
Words	3.7	(2.1)	3.9	(2.1)	2.7	(2.1)	2.0	(1.8)	7.88	.001	G4 vs. G1,G2; G2 vs. G3
Cueing	4.6	(1.3)	4.9	(1.2)	4.3	(1.2)	3.1	(1.4)	13.76	.0001	G4 vs. G1,G2,G3
Recognition	5.6	(0.8)	5.6	(0.7)	5.4	(1.0)	5.2	(1.8)	1.75	.156	none
Semi-complex figure	8.3	(2.1)	7.7	(2.3)	6.8	(2.0)	5.7	(2.9)	11.12	.0001	G4 vs. G1,G2; G1 vs. G3

Note. G1 = zero years of school; G2 = 1–4 years of school; G3 = 5–9 years of school; G4 = 10–24 years of school.

TABLE 4
Analysis of Variance 3 × 4. *F*-values for the Main Effects and Its Interactions in the First Sample (*N* = 192)

	A (Schooling)		B (Age)		A × B	
	F	*p*	*F*	*p*	*F*	*p*
Orientation						
Time	3.11	.047	11.99	.0001	0.91	.494
Space	1.50	.225	1.85	.139	0.92	.478
Person	1.83	.163	3.61	.014	2.05	.065
Attention						
Digits forwards	7.05	.001	1.60	.191	2.04	.064
Digits backwards	4.07	.019	403	.008	1.94	.076
Visual detection	3.49	.033	7.33	.0001	3.96	.001
20 − 3	8.00	.001	4.85	.003	1.99	.071
Coding						
Verbal memory	0.38	.681	2.88	.038	2.07	.059
Copy of a semi-complex figure	13.19	.0001	2.61	.053	0.89	.501
Language						
Naming	3.07	.049	2.93	.035	0.61	.721
Repetition	0.71	.491	1.79	.150	4.35	.0001
Comprehension	14.20	.0001	1.45	.229	1.24	.286
Verbal fluency						
Semantic	1.88	.135	1.20	.309	1.36	.231
Phonol	17.51	.0001	1.32	.268	1.24	.287
Conceptual functions						
Similarities	16.95	.0001	5.12	.002	3.72	.002
Calculation abilities	13.35	.0001	5.43	.001	2.45	.026
Sequences	8.67	.0001	0.52	.665	1.37	.226
Motor functions						
Changing left-hand position	1.16	.315	2.82	.040	0.46	.836
Changing right-hand position	2.40	.093	1.69	.174	0.44	.847
Alternating movements	5.15	.007	0.70	.551	1.14	.340
Opposite reactions	0.82	.442	7.18	.007	0.73	.624
Recall						
Words	1.87	.157	5.55	.001	1.54	.168
Cueing	2.15	.119	12.65	.0001	1.29	.264
Recognition	0.66	.509	1.35	.259	0.45	.839
Semi-complex figure	9.67	.0001	9.04	.0001	0.59	.735

information. Illiterate subjects focused on individual elements of the design and they often misrepresented the relationship of the elements to each other. They followed a piecemeal, fragmented approach that caused repetitive overdetailing. The most frequent type of error (observed in about 70% of the subjects) was the repetition of elements, an error that may have resulted from a fragmented perception. In about 20% of the cases, changing the horizontal orientation of the figure to a vertical orientation was observed. This inversion may have been associated with the tendency to draw a meaningful figure. Sometimes, the subjects themselves named the figure, as a ''house'' or a ''boat.''

DISCUSSION

Current results support the significance of schooling on neuropsychological test performance. For some tests, just 1 or 2 years of formal education may result in a significant difference in test performance. This was true particularly with regard to language understanding, phonological verbal fluency, and conceptual abilities (ability to find similarities).

In the first subject sample, it was evident that, despite using such limited educational range

TABLE 5
Means (*M*) and Standard Deviations (*SD*) Found in the Different NEUROPSI Neuropsychological Tests According to the Educational Level in the Second Sample ($N = 256$)

	Education (Years)							
	0		1–4		5–9		10–19	
Test	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
Orientation								
Time	2.2	(0.8)	2.6	(0.7)	2.8	(0.4)	2.8	(0.5)
Space	1.9	(0.2)	1.9	(0.1)	1.9	(0.1)	1.9	(0.3)
Person	0.9	(0.1)	0.9	(0.3)	1.0	(0.0)	1.0	(0.0)
Attention								
Digits backwards	2.3	(1.0)	2.7	(1.0)	3.4	(0.8)	4.3	(0.8)
Visual detection	10.0	(5.0)	10.8	(4.0)	13.2	(3.2)	13.0	(2.2)
20 − 3	3.3	(2.0)	3.4	(1.7)	4.4	(1.0)	4.8	(0.5)
Coding								
Verbal memory	4.9	(1.1)	4.9	(1.1)	5.5	(0.8)	5.5	(1.0)
Copy of a semi-complex figure	7.3	(2.1)	9.4	(2.3)	11.0	(1.5)	11.4	(1.9)
Language								
Naming	7.0	(0.8)	7.4	(1.0)	7.6	(0.6)	7.9	(0.3)
Repetition	3.8	(0.4)	3.8	(0.5)	3.9	(0.1)	4.0	(0.0)
Comprehension	3.6	(1.3)	4.6	(0.9)	5.5	(0.5)	5.8	(0.6)
Verbal fluency								
Semantic	13.4	(4.6)	14.0	(4.7)	18.2	(5.1)	20.3	(5.3)
Phonol	3.3	(4.0)	6.6	(4.0)	11.1	(5.2)	14.5	(5.3)
Conceptual functions								
Similarities	1.7	(1.9)	3.3	(1.9)	4.9	(1.3)	5.2	(1.6)
Calculation abilities	0.9	(1.0)	1.5	(1.1)	2.2	(0.7)	2.4	(0.8)
Sequences	0.2	(0.3)	0.3	(0.4)	0.7	(0.4)	0.9	(0.3)
Motor functions								
Changing left-hand position	1.0	(0.7)	1.3	(0.8)	1.6	(0.6)	1.7	(0.5)
Changing right-hand position	1.0	(0.7)	1.2	(0.7)	1.6	(0.6)	1.5	(0.7)
Alternating movements	0.9	(0.8)	1.2	(0.7)	1.5	(0.6)	1.9	(0.3)
Opposite reactions	1.7	(0.5)	1.7	(0.4)	1.6	(0.5)	1.8	(0.4)
Recall								
Words	3.0	(2.3)	3.2	(2.1)	4.3	(1.9)	4.7	(1.5)
Cueing	4.1	(1.5)	4.3	(1.3)	4.7	(1.7)	5.2	(1.3)
Recognition	5.4	(1.2)	5.5	(0.8)	5.6	(0.8)	5.4	(1.1)
Semi-complex figure	6.3	(2.3)	7.7	(2.4)	9.4	(2.5)	10.0	(2.2)

(from 0–4 years of formal education), and such a wide age range (from 16–85 years) schooling represented a notoriously more significant variable than age. As a matter of fact, the effects of aging was somehow restricted to memory, visuoperceptual (Visual detection test), and visuoconstructional (Copy of a semi-complex figure test) tests.

When using a large enough range of education, it becomes evident that the educational effect is minor among subjects with relatively high educational levels. In the second analysis, presented in this article, it was found that seven tests established significant differences between the first and second educational group (illiterate vs. 1–4 years of schooling), whereas only two tests established differences between the third and the fourth (5–9 years of education vs. 10–19 years of schooling) educational groups.

Effects of schooling were observed in virtually all the tests, except Orientation in space, Digits forwards, Motor functions —opposite reactions, and Recall—recognition of words. Some of these differences were found when comparing illiterate subjects with subjects with 1 to 2 school years of schooling. Other differences became significant only when extreme educational groups were compared.

The influence of educational variables on test performance represents a well-established

TABLE 6
Differences Among the Four Educational Groups (N = 256)

	F	p	Differences Observed
Orientation			
Time	10.47	.0001	G1 vs. G2,G3,G4
Space	0.40	.750	none
Person	2.90	.094	none
Attention			
Digits forwards	2.90	.094	none
Digits backwards	35.63	.0001	G3 vs. G1,G2; G4 vs. G1,G2,G3
Visual detection	4.48	.005	G1 vs. G3,G4
20 − 3	7.82	.001	G1 vs. G3,G4; G2 vs. G4
Coding			
Verbal memory	4.13	.007	G1,G2 vs. G3,G4
Copy of a semi-complex figure	53.16	.0001	G1 vs. G2,G3,G4; G2 vs. G3,G4
Language			
Naming	5.26	.002	G1 vs. G4
Repetition	5.04	.003	G1 vs. G3,G4
Comprehension	65.94	.0001	G1 vs. G2,G3,G4; G2 vs. G3,G4
Verbal fluency			
Semantic	21.26	.0001	G1 vs. G3,G4; G2 vs. G3,G4
Phonol	40.79	.0001	G1 vs. G2,G3,G4; G2 vs. G3,G4; G3 vs. G4
Conceptual functions			
Similarities	40.08	.0001	G1 vs. G2,G3,G4; G2 vs. G3,G4
Calculation abilities	24.74	.0001	G1 vs. G2,G3,G4; G2 vs. G3,G4
Sequences	33.95	.0001	G1,G2 vs. G3,G4
Motor functions			
Changing left-hand position	9.91	.0001	G1 vs. G3,G4; G2 vs. G4
Changing right-hand position	6.31	.004	G1 vs. G3,G4; G2 vs. G3
Alternating movements	20.33	.0001	G1,G2 vs. G3,G4
Opposite reactions	1.54	.204	none
Recall			
Words	8.41	.0001	G1 vs. G3,G4; G2 vs. G4
Cueing	4.47	.005	G1 vs. G4
Recognition	0.70	.548	none
Semi-complex figure	23.43	.0001	G1 vs. G2,G3,G4; G2 vs. G3,G4

Note. G1 = zero years of school; G2 = 1–4 years of school; G3 = 5–9 years of school; G4 = 10–24 years of school.

observation in psychological measurement (e.g., Anastasi, 1988; Cronbach, 1990). However, recently, the effects of education on neuropsychological test performance have been challenged (e.g., Reitan & Wolfson, 1995; Saykin et al., 1995). For instance, it has been suggested that ‘‘adjusting scores according to age and education may not be a clinically valid procedure for brain-damaged subjects and may only tend to invalidate the raw scores of neuropsychological tests’’ (Reitan & Wolfson, 1995, p. 151). However, when analyzing the subjects' educational level in these reports, it is found the they are comparing subjects with relatively high levels of education. Educational effect on neuropsychological test performance is not a linear effect. Differences between 0 and 3 years of education are usually highly significant; differences between 3 and 6 years of education can be lower; between 6 and 9 are even lower; and so forth. Virtually no differences are expected to be found between, for example, 12 and 15 years of education. Education effect represents a kind of negatively accelerated curve, tending to a plateau. The reason is simple: The ceiling in neuropsychological tests is usually low. If comparing subjects with 11 to 12 and 14 to 15 years of education (see Reitan & Wolfson, 1995; Saykin et al., 1995) very mild or no differences in test performance is expected. This negative finding cannot be generalized to other educational levels. Education,

TABLE 7
Percentage of Performance in the Four Educational Groups (N = 256)

	Education (Years)			
Test	0	1–4	5–9	10–19
Orientation				
Time	73.0	86.6	95.0	95.0
Space	97.0	98.5	98.0	96.0
Person	97.0	89.0	100.0	100.0
Attention				
Digits backwards	39.0	45.0	57.3	70.8
Visual detection	62.5	67.5	82.2	81.2
20 − 3	60.6	68.4	88.4	96.0
Coding				
Verbal memory	81.5	81.5	91.6	91.3
Copy of a semi-complex figure	61.0	78.1	91.3	95.2
Language				
Naming	91.2	93.3	95.6	98.4
Repetition	94.7	95.5	99.2	100.0
Comprehension	60.0	76.6	95.8	96.4
Verbal fluency				
Semantic	66.1	69.0	89.6	100.0
Phonol	23.2	45.9	78.8	100.0
Conceptual functions				
Similarities	28.0	55.0	81.1	85.3
Calculation abilities	30.0	51.0	73.3	79.6
Sequences	14.0	28.0	71.0	87.0
Motor functions				
Changing left-hand position	52.0	64.0	79.0	86.0
Changing right-hand position	52.0	60.0	80.5	82.0
Alternating movements	43.5	57.5	77.5	92.5
Opposite reactions	87.5	88.0	82.0	92.5
Recall				
Words	50.0	53.3	71.1	78.6
Cueing	68.0	72.0	78.5	85.5
Recognition	90.3	90.8	93.8	89.1
Semi-complex figure	54.1	64.6	78.3	83.3

Note. In the verbal fluency subtests, maximum performance was considered 100%.

however, may represent the most significant variables on neuropsychological test performance.

The very low scores observed in neuropsychological tests in illiterate subjects can be partially due to differences in learning opportunities of those abilities that the examiner considers most relevant, although, evidently, they are not the really relevant abilities for the illiterate subjects' survival. They can be also due to the fact that these subjects are not used to being tested (i.e., they have not learned how to behave in a testing situation). Furthermore, testing itself represents a nonsense situation that illiterate subjects may find surprising and absurd. As mentioned above, a significant percentage of illiterate subjects inverted the semi-complex figure in order to draw a meaningful figure (e.g., a ''house'' or a ''boat''). Nonexistent things simply cannot be represented.

The possibility of some intervening variables, that is, factors associated with illiteracy, should be taken into consideration. Illiteracy is most frequently associated with poverty and low socioeconomic status (SES). An association between nervous system disorders and low SES has been pointed out (e.g., Alvarez, 1983). Some research studies have shown that low SES subjects receive quantitatively and qualitatively less stimulation at home as compared with the high SES subjects. This differential stimulation contributes to the development of different behavioral styles (Cravioto & Arrieta, 1982). The results of these research studies indicate that development in an impoverished social environment results in insufficient stimulation, which in turn alters the development of the central nervous system. It has been well established that some nervous system pathologies, for example, epilepsy, are significantly more frequent in developing countries and in low SES subjects than in industrialized countries and high SES individuals (e.g., Gómez, Arciniegas, & Torres, 1978; Gracia, Bayard, & Triana, 1988).

The analysis of performance of illiterate populations in neuropsychological measures suggests that cognitive abilities, as measured by standard neuropsychological tests, are significantly associated with schooling (Rosselli, 1993). It is a mistake to assume that the inability to perform simple cognitive tasks—as those incorporated in current neuropsychological test batteries, necessarily means abnormal brain function. The degree of literacy can often represent the crucial variable. The influence of literacy seems to go farther: Literacy may somehow change the brain organization of cognition. It is a fact that educational and cultural variables may affect not only handedness (i.e., Ardila et al., 1989; Bryden, Ardila, & Ardila, 1993), but also the degree of hemispheric dominance for language and, quite likely, other cognitive abilities. Matute (1988) compared three groups of Mexican right-handed subjects: brain-damaged illiterates, brain-damaged literates, and normal illiterates. An aphasia test was given to all three subject groups as part of a neuropsychological assessment. All left-hemisphere–damaged illiterate subjects presented with aphasia, and none of the illiterate group presented with aphasia after right-hemisphere damage. The aphasia was, however, less severe in the illiterate group than in the literate. The literate group presented a higher number of errors, with lower scores in the aphasia subtests than the illiterate brain-damaged individuals.

Lecours et al. (1987a, 1987b, 1988) studied some relationships between brain damage and schooling with regard to aphasic impairments of language. The authors concluded from their results that: (a) there was a greater right-hemisphere language involment in illiterate than in well-educated subjects; and (b) left-stroke school-educated subjects seemed to be ‘‘sicker,’’ as it were, than their illiterate counterparts, that is: (a) the classic symptoms of aphasia (suppression stereotype, jargonaphasia) are more apparent among left-stroke literates than among left-stroke illiterates; and (b) auditory comprenhension was more frequently impaired among the left-literate patients. Lecours et al. (1987b) studied also the influence of education on unilateral neglect syndrome. They analyzed a large sample of right-handed unilingual brain-damaged subjects: illiterates (left stroke and right stroke) and literates (left stroke and right stroke). Evidence of unilateral neglect syndrome was found in both left- and right-brain–damaged literates and illiterates. Their results provide no indication that tropisms were globally stronger depending on the side of the lesion or on the educational level of the subjects. Rosselli, Rosselli, Vergara, and Ardila (1985), however, reported a higher frequency of right hemi-spatial neglect in low-educated subjects.

Studies of brain-damaged illiterate subjects when compared with brain-damaged literate subjects conclude: (a) literacy does not change the dominance of the left hemisphere for language; illiterate as well as literate subjects present with aphasia most often after a left-brain–damage, and not after a right-brain–damage; and (b) it seems, however, that the righ hemisphere has more participation on language in illiterate subjects. There is a general consensus that left-damaged literates present a higher number of errors in aphasia tests than left-damaged illiterates (Lecours et al., 1988; Matute, 1988), and that right-damaged illiterates present more frequent lower performance in aphasia tests than right-brain–damage literates (Lecours et al., 1987a, 1987b).

Writing has just a 5,000- to 6,000-year history, and obviously prehistoric man was illiterate. Cultural knowledge and cognitive abilities mediated through written language represent a recent historical acquisitions. The analysis of illiteracy can significantly increase the understanding about brain organization of cognition under normal and abnormal conditions.

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