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
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
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 x 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 x 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).

**TABLE 1**

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Education 16–30</th>
<th>31–50</th>
<th>51–65</th>
<th>66–85</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td>1–2 years</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td>3–4 years</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>64</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>192</td>
</tr>
</tbody>
</table>
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 trisyllabic 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.


9.1.3. Recognition. The examiner reads 14 different words and the subject must tell which ones were previously presented. Maximum score = 6.


In total, 26 different scores are obtained. Maximum total score is 130. Testing was performed in a single session. 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, Spontaneous 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

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

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

<table>
<thead>
<tr>
<th>Test</th>
<th>16–30</th>
<th>31–50</th>
<th>51–65</th>
<th>66–85</th>
<th>F</th>
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<td>G2</td>
<td>G3</td>
<td>G4</td>
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<td>5.7 (4.6)</td>
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<tr>
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<td>1.5 (1.1)</td>
<td>1.6 (1.1)</td>
<td>2.59 .054</td>
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<td>0.2 (0.4)</td>
<td>0.2 (0.4)</td>
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<td><strong>Motor functions</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing left-hand position</td>
<td>1.1 (0.8)</td>
<td>1.4 (0.6)</td>
<td>1.2 (0.6)</td>
<td>1.0 (0.8)</td>
<td>2.58 .054</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>Changing right-hand position</td>
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<td>1.1 (0.5)</td>
<td>1.1 (0.8)</td>
<td>1.3 (0.7)</td>
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</tr>
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<td>1.0 (0.6)</td>
<td>0.9 (0.7)</td>
<td>0.9 (0.8)</td>
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</tr>
<tr>
<td>Opposite reactions</td>
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<td>1.8 (0.4)</td>
<td>1.8 (0.4)</td>
<td>1.5 (0.6)</td>
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<td>G4 vs. G1,G2,G3</td>
<td></td>
</tr>
<tr>
<td><strong>Recall</strong></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Words</td>
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<td>3.9 (2.1)</td>
<td>2.7 (2.1)</td>
<td>2.0 (1.8)</td>
<td>7.88 .001</td>
<td>G4 vs. G1,G2; G2 vs. G3</td>
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<td>4.9 (1.2)</td>
<td>4.3 (1.2)</td>
<td>3.1 (1.4)</td>
<td>13.76 .0001</td>
<td>G4 vs. G1,G2,G3</td>
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</tr>
<tr>
<td>Recognition</td>
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<td>5.6 (0.7)</td>
<td>5.4 (1.0)</td>
<td>5.2 (1.8)</td>
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<td>7.7 (2.3)</td>
<td>6.8 (2.0)</td>
<td>5.7 (2.9)</td>
<td>11.12 .0001</td>
<td>G4 vs. G1,G2; G1 vs. G3</td>
<td></td>
</tr>
</tbody>
</table>

**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)

<table>
<thead>
<tr>
<th>A (Schooling)</th>
<th>B (Age)</th>
<th>A × B</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>Orientation</td>
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</tr>
<tr>
<td>Time</td>
<td>3.11</td>
<td>.047</td>
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<td>Space</td>
<td>1.50</td>
<td>.225</td>
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<td>Person</td>
<td>1.83</td>
<td>.163</td>
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<td>Attention</td>
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<tr>
<td>Digits forwards</td>
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<td>.001</td>
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<td>Digits backwards</td>
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<td>.019</td>
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<tr>
<td>Visual detection</td>
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<td>.033</td>
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<tr>
<td>Orientation</td>
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<td>Digits forwards</td>
<td>8.00</td>
<td>.001</td>
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<td>Coding</td>
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<tr>
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<td>.681</td>
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<td>.0001</td>
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<tr>
<td>Language</td>
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<td></td>
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<tr>
<td>Naming</td>
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<td>.049</td>
</tr>
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<td>Repetition</td>
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<td>.491</td>
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<td>.0001</td>
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<td>Verbal fluency</td>
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<td>Similarities</td>
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<td>.0001</td>
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<td>.0001</td>
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<tr>
<td>Sequences</td>
<td>8.67</td>
<td>.0001</td>
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<td>Motor functions</td>
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<td>.119</td>
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<td>.509</td>
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<td>.0001</td>
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</table>

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)

<table>
<thead>
<tr>
<th>Education (Years)</th>
<th>Test</th>
<th>M (SD)</th>
<th>M (SD)</th>
<th>M (SD)</th>
<th>M (SD)</th>
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<tbody>
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<td>2.6 (0.7)</td>
<td>2.8 (0.4)</td>
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<td></td>
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<td>1.9 (0.1)</td>
<td>1.9 (0.3)</td>
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<td>3.3 (2.0)</td>
<td>3.4 (1.7)</td>
<td>4.4 (1.0)</td>
<td>4.8 (0.5)</td>
</tr>
<tr>
<td></td>
<td>Visual detection</td>
<td>10.0 (5.0)</td>
<td>10.8 (4.0)</td>
<td>13.2 (3.2)</td>
<td>13.0 (2.2)</td>
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<td>1–4</td>
<td>Coding Verbal memory</td>
<td>4.9 (1.1)</td>
<td>4.9 (1.1)</td>
<td>5.5 (0.8)</td>
<td>5.5 (1.0)</td>
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<tr>
<td></td>
<td>Copy of a semi-complex figure</td>
<td>7.3 (2.1)</td>
<td>9.4 (2.3)</td>
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<td>11.4 (1.9)</td>
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<tr>
<td>5–9</td>
<td>Language Naming</td>
<td>7.0 (0.8)</td>
<td>7.4 (1.0)</td>
<td>7.6 (0.6)</td>
<td>7.9 (0.3)</td>
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<tr>
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<td>Repetition</td>
<td>3.8 (0.4)</td>
<td>3.8 (0.5)</td>
<td>3.9 (0.1)</td>
<td>4.0 (0.0)</td>
</tr>
<tr>
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<td>Comprehension</td>
<td>3.6 (1.3)</td>
<td>4.6 (0.9)</td>
<td>5.5 (0.5)</td>
<td>5.8 (0.6)</td>
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<tr>
<td></td>
<td>Verbal fluency Semantic</td>
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<td>14.0 (4.7)</td>
<td>18.2 (5.1)</td>
<td>20.3 (5.3)</td>
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<td>Phonol</td>
<td>3.3 (4.0)</td>
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<td>11.1 (5.2)</td>
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<td>10–19</td>
<td>Conceptual functions Similarities</td>
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<td>5.2 (1.6)</td>
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<td></td>
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<td>1.5 (1.1)</td>
<td>2.2 (0.7)</td>
<td>2.4 (0.8)</td>
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<td>Sequences</td>
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<td>0.3 (0.4)</td>
<td>0.7 (0.4)</td>
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<td>1.6 (0.6)</td>
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<td>Changing right-hand position</td>
<td>1.0 (0.7)</td>
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<td>1.5 (0.7)</td>
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<td>1.5 (0.6)</td>
<td>1.9 (0.3)</td>
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<td>Opposite reactions</td>
<td>1.7 (0.5)</td>
<td>1.7 (0.4)</td>
<td>1.6 (0.5)</td>
<td>1.8 (0.4)</td>
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<td>Recall Words</td>
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<td>3.2 (2.1)</td>
<td>4.3 (1.9)</td>
<td>4.7 (1.5)</td>
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<td>Cueing</td>
<td>4.1 (1.5)</td>
<td>4.3 (1.3)</td>
<td>4.7 (1.7)</td>
<td>5.2 (1.3)</td>
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<td>Recognition</td>
<td>5.4 (1.2)</td>
<td>5.5 (0.8)</td>
<td>5.6 (0.8)</td>
<td>5.4 (1.1)</td>
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<td>10.0 (2.2)</td>
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</tbody>
</table>

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)

<table>
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<th></th>
<th>F</th>
<th>p</th>
<th>Differences Observed</th>
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</thead>
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<td></td>
</tr>
<tr>
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<td>.750</td>
<td>none</td>
</tr>
<tr>
<td>Person</td>
<td>2.90</td>
<td>.094</td>
<td>none</td>
</tr>
<tr>
<td>Attention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digits forwards</td>
<td>2.90</td>
<td>.094</td>
<td>none</td>
</tr>
<tr>
<td>Digits backwards</td>
<td>35.63</td>
<td>.0001</td>
<td>G3 vs. G1, G2; G4 vs. G1, G2, G3</td>
</tr>
<tr>
<td>Visual detection</td>
<td>4.48</td>
<td>.005</td>
<td>G1 vs. G3, G4</td>
</tr>
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<td>20 – 3</td>
<td>7.82</td>
<td>.001</td>
<td>G1 vs. G3, G4; G2 vs. G4</td>
</tr>
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<td></td>
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<tr>
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<td>.007</td>
<td>G1, G2 vs. G3, G4</td>
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<tr>
<td>Copy of a semi-complex figure</td>
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<td>.0001</td>
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<td>.02</td>
<td>G1 vs. G4</td>
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<td>Repetition</td>
<td>5.04</td>
<td>.03</td>
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</tr>
<tr>
<td>Comprehension</td>
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<td>.0001</td>
<td>G1 vs. G2, G3, G4; G2 vs. G3, G4</td>
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<tr>
<td>Verbal fluency</td>
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<td></td>
<td></td>
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<tr>
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<td>.0001</td>
<td>G1 vs. G2, G3, G4; G2 vs. G3, G4; G3 vs. G4</td>
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<td>Conceptual functions</td>
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<td></td>
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<tr>
<td>Similarities</td>
<td>40.08</td>
<td>.0001</td>
<td>G1 vs. G2, G3, G4; G2 vs. G3, G4</td>
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<td>.0001</td>
<td>G1, G2 vs. G3, G4</td>
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<td>Motor functions</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Changing left-hand position</td>
<td>9.91</td>
<td>.0001</td>
<td>G1 vs. G3, G4; G2 vs. G4</td>
</tr>
<tr>
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<td>6.31</td>
<td>.004</td>
<td>G1 vs. G3, G4; G2 vs. G3</td>
</tr>
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<td>Alternating movements</td>
<td>20.33</td>
<td>.0001</td>
<td>G1, G2 vs. G3, G4</td>
</tr>
<tr>
<td>Opposite reactions</td>
<td>1.54</td>
<td>.204</td>
<td>none</td>
</tr>
<tr>
<td>Recall</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Words</td>
<td>8.41</td>
<td>.0001</td>
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<td>.005</td>
<td>G1 vs. G4</td>
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<td>Recognition</td>
<td>0.70</td>
<td>.548</td>
<td>none</td>
</tr>
<tr>
<td>Semi-complex figure</td>
<td>23.43</td>
<td>.0001</td>
<td>G1 vs. G2, G3, G4; G2 vs. G3, G4</td>
</tr>
</tbody>
</table>

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 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)

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

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 stimu-
lation, 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, & Tri-
ana, 1988).

The analysis of performance of illiterate populations in neuropsychological measures sug-
ests that cognitive abilities, as measured by standard neuropsychological tests, are signifi-
cantly 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 rep-
resent the crucial variable. The influence of literacy seems to go farther: Literacy may some-
how 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 indi-
viduals.

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 involvement 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 (sup-
pression stereotype, jargonaphasia) are more apparent among left-stroke literates than among
left-stroke illiterates; and (b) auditory comprehension 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 glob-
ally 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
hemispatial 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
t hemisphere has more participation on language in illiterate subjects. There is a general con-
sensus 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 il-
literate. 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.

REFERENCES


Matute, E. (1988). El aprendizaje de la lectoescritura y la especialización hemisférica para el lenguaje [Reading and writing learning a hemispheric specialization for language]. In A. Ardila & F. Ostrosky (Eds.), *Lenguaje oral y escrito* (pp. 310–338), Mexico: Trillas.


