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NEUROPSYCHOLOGICAL TEST PERFORMANCE IN ILLITERATES

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Abstract

The purpose of this study was to further analyze the effects of education across different ages range 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 totally 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' age ranged from 16 to 85 years. In the second analysis the illiterate subjects were further matched by age and sex with individuals with 1-4, 5-9 and 10-19 years of formal education. The Spanish version of the NEUROPSI neuropsychological test battery (Ostrosky, Ardila & Rosselli, 1997) was used. Results indicated a robust education 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 zero to four years of formal education), and such a wide age range (from 16 to 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.

Illiterates represent a non-neglectable proportion of the world population (about one third of the world people are illiterates; Unicef, 1995). Writing has only some five-six thousand years in human history and just a few centuries ago, reading and writing abilities were simply uncommon among the general population. It may be assumed that the acquisition of the reading and writing skills may have somehow 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: 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 consequnece, not only to discern the influence of schooling background on neuropsychological test performance, but also contributes to obtain a better understanding about 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). In consequence, 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 & Rosas, 1989; Ardila, Rosselli & Ostrosky, 1992; Ardila, Rosselli & Puente, 1994; Bornstein & Suga, 1988; Finlayson, Johnson & Reitan, 1977; Heaton, Grant, & Mathews, 1986; Lecours et al., 1987a, 1987b, 1988; Leckliter & Matarazzo, 1989; Ostrosky et al, 1985, 1986; Rosselli, Ardila & Rosas, 1990). In general, some tests have been observed to be notoriously more sensitive to educational variables (e.g., language tests) than others (e.g., the Wisconsin Card Sorting Test; Rosselli & Ardila, 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 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, Ardila & Rosas, 1990; Lecours et al., 1987a, 1987b, 1988). Without a careful consideration of the educational variables, neuropsychology runs the risk of finding brain pathology where there are only educational differences. As an illustration of this point, Bertolucci et al (1994) selected a 530-subject sample of individuals with diverse educational background. They noted that, not only that educational level represented an extremely significant predictor in the Mini-Mental State Exam (Folstein, Folstein, & McHugh, 1975) scores, but also that, the cut-off point for illiterates should be set in only 13 points out of 30. This 13-point score is usually considered as significantly abnormal for any schooled 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. (1) A group of 64 totally illiterate (zero 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 what is indeed 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. (2) These 64 illiterate subjects were further matched by age and sex with individuals with 1-4, 5-9 and 10-19 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.

SEE TABLE 1

Method

Subjects

Two different samples of illiterates were selected. The first sample was collected 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: (1) Zero school attendance, as a result of economical restrictions, and/or long distances between home and school during childhood; (2) Inability to write their own name; for this purpose, all the subjects were requested to write their names; only those subject unable to do it, were included in the illiterate sample; (3) Normal performance in daily life activities (i.e., normal functional intelligence) according to the subject's sociocultural environment.

A neurological and psychiatric screening questionnaire was used to rule out previous neurological and psychiatric conditions such as: brain injury, cerebrovascular disease, epilepsy, Parkinson's disease, psychiatric hospitalizations, and so on. A handedness questionnaire was also presented. Further, the NEUROPSI neuropsychological test battery was individuality administered. All the subjects were non-paid 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, submitted) 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 which 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 one minute. Two scores are obtained: number of correct responses (maximum score = 16), and number of errors.

2.3. 20 minus 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 notoriously simplier is presented to the subject. The subject is instructed to copy the figure on his or her best. 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. Succesful 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 was used. One point was given to 0-5 words; two points to 6-8 words; three points to 9-14 words; and four points to 15 or more words in a minute. Intrusions and perseverations are noted.

4.5. Phonological verbal fluency (words begining with the letter F). Two scoring systems were used: (a) the total number of correct words; and (b) A 4-point scale was developed. One point was given to 0-3 words; two points to 4-6 words; three points to 7-9 words; and four points to 10 or more words in a minute. Intrusions and perseverations 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 copy 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. Changing 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, with a three months interval. Interrater reliability was determined by independent scores of the NEUROPSI performance of 20 subjects by two examiners. The test-retest reliability score was O.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 (illiterates) and the third educational (3-4 school years) group were observed in all the tests -except Orientation in person. 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.

SEE TABLE 2

An analysis of variance (ANOVA) was used to analyze differences among the three educational groups (illiterates, 1-2 of school, and 3-4 years of school). The significance level was set at $p < 0.05$ 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 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 one-two years of education made a statistically significative 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, test scores tended to decrease across the age ranges. Nonetheless, in six tests (Digits backwards, 20 minus 3, Naming, Repetition, Calculation abilities, and Changing right-hand position) scores increase between the first (16-30 years) and the forth (66-85 years) age range

SEE TABLE 3

An analysis of variance (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 x 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.

SEE TABLE 4

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 1-4, 5-9 and 10-19 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 was over four times higher than in the illiterate sample.

SEE TABLE 5

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) statistically significant differences were found between the third (5-9 school years) and the forth (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.

SEE TABLE 6

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 illiterates is below half of the performance observed in subjects with the highest educational level: Phonological verbal fluency, Calculation abilities, Sequences, and Alternating movements. These are in consequence tests extremely sensitive to the educational effects. For the rest of the neuropsychological tests performance by illiterates was over 50% of the performance observed in subjects with the highest educational level.

SEE TABLE 7

In addition to the test scores analysis, a qualitative analysis of tests performance of illiterates was also carried out. Several qualitative differences were observed. For example, the strategy for copying the Semi-complex figure was overtly dependent of featural 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 over detailing. 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 one or two 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 (from zero to four years of formal education), and such a wide age range (from 16 to 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 paper, it was found that seven tests established significant differences between the first and second educational group (illiterates vs 1-4 years of schooling), whereas only two test established differences between the third and the forth (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 1-2 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 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 zero and three year of education are usually highly significant; differences between three and six years of education can be lower; between six and nine are even lower; and so forth. Virtually no differences are expected to be found between, for example, 12 and 15 years of education. It means, education effect represents kind of negatively accelerated curve, tending to a plateau. The reason is simple: ceiling in neuropsychological tests is usually low. If comparing subjects with about 11-12 and 14-15 years of education (see Reitan & Wolfson, 1995; Saykin et al, 1995) very mild or none differences in test performance is in consequence expected. This negative finding cannot be generalized to other educational levels. Education anyhow may represent the most significant variables on neuropsychological test performance.

The very low scores observed in neuropsychological tests in illiterates 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 illiterates' survival. They can be also due to the fact that, illiterates are not used to be tested (i.e., they have not learned how to behave in a testing situation). Furthermore, testing itself represents a nonsense situation that illiterate people may find surprising and absurd. As mentioned above, a significant percentage of illiterates inverted the Semi-complex figure in order to draw a meaningful figure (e.g., a "house" or a "boat"). Non existing 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 in comparison 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., Gȯmez, 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, 1989a; Bryden et al, 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 hemiphere-damaged illiterate subjects presented aphasia, and none illiterate presented aphasia after right hemisphere damage. The aphasia was, however, less severe in the illiterate group than in the literate one. The literate group presented a higher number of errors, with lower scores in the aphasia subtests than the illiterate brain-damaged individulas.

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: (1) there was a greater right-hemisphere language involment in illiterates than in the well-educated subjects; and (2) left-stroke school-educated subjects seemed to be 'sicker', as it were, than their illiterate counterparts, that is: (a) the classical 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 illiterates when compared with brain-damaged literates allow to conclude: (1) literacy do not change the dominance of the left hemisphere for language; illiterates as well as literates present aphasia most often after a left brain damage, and not after a right brain damage; and (2) 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 munber of errors in aphasia tests than left-damaged illiterates (Lecours et al, 1988; Matute, 1988), and that right-damaged illiterates present more frecuently lower performance in aphasia tests than right brain-damage literates (Lecours et al, 1987a, 1987b).

Writing has just some five to six thousand year history, and obviously prehistorical 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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Table 1.

Distribution of the first sample

	Age				
Education	16-30	31-50	51-65	66-85	Total
Illiterates	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

Table 2.

Means and standard deviations 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					
Test	0	1-2	3-4	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 minus 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 pos	1.1 (0.7)	1.2 (0.7)	1.3 (0.7)	0.59	.551	none
Changing right-hand pos	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

Table 3.

Means and standard deviations found in the different "Neuropsi" neuropsychological tests according to age in the first sample (N = 192). Differences among the groups are pointed out.

	Age						
Test	16-30	31-50	51-65	66-85	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 vsG3,G4; G2 vs G4
20 minus 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)	7.6 (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 pos	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
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

Table 4.

ANOVA 3 X 4. F-values for the main effects and its interactions in the first sample (N = 192).

	A (schooling)		B (age)		A x 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	4.03	.008	1.94	.076
Visual detection	3.49	.033	7.33	.0001	3.96	.001
20 minus 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 pos	1.16	.315	2.82	.040	0.46	.836
Changing right-hand pos	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

Table 5.

Means and standard deviations found in the different NEUROPSI neuropsychological tests according to the educational level in the second sample (N = 256).

	Education			
Test	0 years	1-4 years	5-9 years	10-19 years
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 minus 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 pos	1.0 (0.7)	1.3 (0.8)	1.6 (0.6)	1.7 (0.5)
Changing right-hand pos	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)

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 minus 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 pos	9.91	.0001	G1 vs G3,G4; G2 vs G4
Changing right-hand pos	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

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 minus 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 pos	52.0	64.0	79.0	86.0
Changing right-hand pos	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 as 100%.