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Learning to read is much more than learning to read: A neuropsychologically based reading program

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Abstract

Departing from the observation that illiterates significantly underscore in some neuropsychological tests, a learning-to-read method named NEUROALFA was developed. NEUROALFA is directed to reinforce these underscored abilities during the learning-to-read process. It was administered to a sample of 21 adult illiterates in Colima (Mexico). Results were compared with 2 control groups using more traditional procedures in learning to read. The NEUROPSI neuropsychological test battery was administered to all the participants before and after completing the learning-to-read training program. All 3 groups presented some improvement in the test scores. Gains, however, were significantly higher in the experimental group in Orientation in Time, Digits Backward, Visual Detection, Verbal Memory, Copy of a Semi-Complex Figure, Language Comprehension, Phonological Verbal Fluency, Similarities, Calculation Abilities, Sequences, and all the recall subtests, excluding Recognition. Performance in standard reading tests was also significantly higher in the experimental group. Correlations between pretest NEUROPSI scores and reading ability were low. However, correlations between posttest NEUROPSI scores and reading scores were higher and significant for several subtests. Results are interpreting as supporting the assumption that reinforcement of those abilities in which illiterates significantly underscore results in a significant improvement in neuropsychological test scores and strongly facilitates the learning-to-read process. The NEUROALFA method of teaching reading to adult illiterates is beginning to be used extensively in Mexico. To our knowledge, this is the first attempt to apply neuropsychological principles to social problems. (*JINS*, 2000, *6*, 789–801.)

Keywords: Illiteracy, Reading, Neuropsychological testing, Cognitive abilities

INTRODUCTION

A significantly decreased neuropsychological test performance has been documented in illiterate individuals (Ardila et al., 1989; Goldblum & Matute, 1986; Lecours et al. 1987a, 1987b, 1988; Manly et al., 1999; Ostrosky et al., 1998; Reis & Castro-Caldas, 1997; Rosselli et al., 1990). Lowered scores are observed in most cognitive domains, including naming, verbal fluency, verbal memory, visuoperceptual abilities, conceptual functions, and numerical abilities. Language repetition can be normal for meaningful words, but abnormal for pseudowords (Reis & Castro-Caldas, 1997; Rosselli et al., 1990). Similarly, copying meaningful figures can be easier than copying nonsense figures (Ostrosky et al., 1998). Furthermore, for illiterate people to use concrete situations can be notoriously easier than using nonreal and abstract elements. When the information is related to real life, it can be significantly easier to understand. Thus, for the illiterate person, it is easier to solve the arithmetical operation "If you go to the market and initially buy 12 tomatoes and place them in a bag and later on, you decide to buy 15 additional tomatoes, how many tomatoes will you have in your bag?" than the operation, "How much is 12 plus 15?" Semantic verbal fluency is easier than phonological verbal fluency (Reis & Castro-Caldas, 1997; Rosselli et al., 1990), seemingly because phonological abstraction is extremely difficult for the illiterate person. Semantic verbal fluency requires the use of concrete elements (animals, fruits) whereas phonological fluency is tapping a metalinguistic ability.

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It could be conjectured that learning to read stimulates the development of certain cognitive abilities: verbal memory, visuoperceptual abilities, phonological abstraction, conceptualization, verbal knowledge, etc. As a matter of fact, 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 (Laurendeau-Bendavid, 1977) and functional brain organization (Castro-Caldas et al., 1998) have been pointed out. Conversely, training these abilities may make it easier to learn to read and to write.

It was hypothesized that a teaching-to-read program directed to reinforce some specific neuropsychological abilities could facilitate the learning-to-read process. Departing from the analysis of illiteracy, the abilities that should be most stimulated and reinforced include verbal memory, visuoperceptual abilities, and phonological awareness. Furthermore, a successful teaching-to-read program should at best use personal and concrete information dealing directly with the learner's personal situations and interests.

In Mexico, the National Institute of Adult Education *(Instituto Nacional para la Educación de los Adultos*, INEA) has a large program directed to teach adult people to read and write. Approximately 1,135,250 adults attend this program every year, but only 28.63% successfully learn to read (INEA, 1998). The rest do not complete the program or simply fail in learning to read.

Two different methods are used by the INEA when teaching to read and to write:

1. Global method: *Método Global de Alfabetización con el Nuevo Enfoque para la Educación Básica de los Adultos* known as NEEBA (INEA, 1994). It begins by exploring different written materials (letters, newspapers, etc.). The purpose is to learn to read using the words that the learner can find in his or her environment. It includes 46 lessons grouped in eight units. Each lesson takes about 1 hr. It can be developed in 6 to 12 months depending upon the numbers of hours working weekly and the student's own rate of progress. The general structure of the NEEBA is presented in Appendix 1.

2. Method Express (INEA, 1990) relies on a phonological strategy. The letters included in the student's name are initially used. These letters are analyzed and the idea that words are formed by discrete sounds is reinforced. Further, it moves to other common words, emphasizing the relationships between phonemes and graphemes. Complex letter combinations are introduced later. It takes about 20 hr. It is considered a kind of brief and basic learning-to-read method. In a significant extent it is an individualized method, that depends upon each learner. There is no sequence of lessons and the Express method can be regarded as a rather elementary learning-to-read procedure.

The purposes of this study were (1) to develop a new method to teach adults to read and write, departing from current knowledge about neuropsychological test performance in illiterates, using this new method (named NEUROALFA); and (2), to compare the efficiency of the NEUROALFA method with the two traditional methods used in Mexico to teach adult illiterates to read and write. Changes in neuropsychological test performance were analyzed.

METHODS

Research Participants

Sixty illiterate individuals who first attended the INEA in Colima City (Mexico) were selected. Ages ranged from 16 to 50 years. This group was divided into three subgroups matched by age and gender:

1. Group 1 (G1; 10 men, 11 women; *M* age = 33.22, *SD* = 12.12): The NEUROALFA method was administered.

2. Group 2 (G2; 10 men, 11 women; *M* age = 33.14, *SD* = 11.21) was administered the NEEBA method.

3. Group 3 (G3; 8 men, 10 women; *M* age = 32.90, *SD* = 12.15) was administered the Express method.

Once all the participants were selected, they were randomly assigned to one of the three groups. However, it was further necessary to make some changes in the groups composition, in order to have a similar number of males and females and a similar age distribution in each group.

All the participants had a normal performance in daily life activities. All were active and functionally independent (i.e., normal functional intelligence) according to the participant's own sociocultural environment. All were living in the east area of Colima City, which is considered an extremely poor area. The University of Colima has a public health program known as *UNI-Colima*. This health program not only attends medical issues and distributes health information, but also recommends people to participate in alphabetization programs. All participants in this research were referred to the INEA by the UNI-Colima program. This is a customary procedure during the development of public health programs. Participants were unqualified workers, maids, and housewives. All participants were considered to be illiterate as a result of lack of schooling opportunities, and not as a result of poor academic performance. This lack of schooling opportunities included extremely poor economical conditions requiring the participant to work instead of attending school; absence of close schools in participants coming from rural areas; and parents' preference to send boys but not girls to school. This last situation was observed in several illiterate women. Some participants could recognize a few letters and even write their own name without recognizing its phonology, but most of them "signed" using the fingerprint. They did, however, recog-

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nize diverse logographic signs, such as "STOP," and the logographically written names of many commercial products (cigarettes, beverages, etc).

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 the like. A handedness questionnaire was also presented. Four individuals were not included in the study due to history of alcohol abuse.

The NEUROPSI neuropsychological test battery (Ostrosky et al., 1997, 1999) was individually administered to all participants before and after the learning-to-read training. Regular INEA teachers administered all the three learning-to-read methods. A volunteer INEA teacher was trained to administer the NEUROALFA method. All the classes took place in the INEA facility in Colima City. All the teachers were aware that a research study about methods in learning to read was in progress, but they did not have any knowledge about the specific purposes and hypotheses of the study. It is customary in the INEA programs to encourage the participants at best. Participants in all groups were told that they were improving strongly and would make significant progress if they followed the instructions. Thus, in all groups the participants assumed that the best effort was made and the best method had been used. Class groups included only 2 or 3 students simultaneously working with one teacher.

Once the training was completed, all the 60 participants were evaluated in reading ability.

The NEUROALFA Teaching-to-Read Method

It was conjectured that a successful method to teach adult illiterates to read and write should have the following characteristics:

1. It should reinforce those abilities in which illiterates underscore in common neuropsychological tests. Such abilities include: (a) phonological abstraction, (b) semantic categorization, (c) finding similarities, (d) visuoperceptual abilities, (e) verbal memory, and (f) abstracting abilities.

2. Concrete and personal situations should be preferred and used whenever possible, such as family issues, home activities, everyday use of written language, personal documents, etc.

Based on these considerations, a teaching-to-read method called NEUROALFA was developed. It includes an instructor's manual and a reading book for the student. The instructor's manual includes 34 exercises grouped in 10 lessons. Each lesson takes about 3 to 4 hr, and each exercise takes about 1 hr. NEUROALFA can be developed in about 3 months, working 3 times weekly. Total administration time can be about 40 hr. The general structure of the different NEUROALFA lessons is presented in Appendix 2.

NEUROALFA attempts to emphasize those abilities in which illiterates frequently get low scores in common neuropsychological tests. These abilities are reinforced during the learning-to-read process, not in separate training sessions. These are supposed to be the abilities required to read (e.g., phonological awareness), and amplified during the learning-to-read process.

Comparing NEUROALFA and NEEBA methods, it is observed that NEUROALFA includes the following types of exercises, not found in the NEEBA method: (1) exercises emphasizing phonological awareness; phoneme discrimination, phonological similarity, decomposition of words in sounds and letters, to group words with common phonemes, and cross-words; (2) exercises of semantic associations, (3) spatial exercises: spatial orientation of words, spatial discrimination of letters; (4) proverb interpretation; and (5) exercises emphasizing verbal memory, namely, to recall sentences.

Neuropsychological Testing Instrument

The Spanish version of the NEUROPSI neuropsychological test battery (Ostrosky et al., 1997, 1999) was individually administered twice, at the beginning and at the end of the learning-to-read program. NEUROPSI includes the following sections:

1. *Orientation*: Time (day, month, and year), Place (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 Backward*: up to six digits. Maximum score = 6 points.
   2.2. *Visual Detection*: On a sheet that includes 16 different figures, each one repeated 16 times, the participants 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 min. 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 participant 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 much sim-

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pler is presented to the participant. The participant is instructed to copy the figure as well as possible. 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 participant 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 participant is asked to repeat one monosyllable word, one three-syllable 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 participant. The easiest one is, "Point to 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: the total number of correct words, and a 4-point scale. One point was given for zero to five words, 2 points for six to eight words; 3 points for 9 to 14 words, and 4 points for 15 or more words in 1 min. Intrusions and perseverations were noted.
   4.5. *Phonological Verbal Fluency* (words beginning with the letter 'F'): Two scoring systems were used: (a) the total number of correct words and (b) a 4-point scale that was developed. One point was given for zero to three words, 2 points for four to six words, 3 points for seven to nine words; and 4 points for 10 or more words in 1 min. Intrusions and perseverations were noted.

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

6. *Writing*: To write to dictation a six-word sentence; and to 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 and the participant must find the similarity. An example is provided. Each one is scored as zero (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 participant 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 Hand Movements*: 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 participant must show the fist; if the examiner shows the fist, the participant 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 participant 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 session. Administration time is 25 to 30 min. Reading and writing sections were not included. Normative results and reliability of this test battery are presented elsewhere (Ostrosky et al., 1999).

Reading Testing

Two types of tests were used:

1. *Texts to assess oral and silent reading (Ostrosky-Solís, 1990)*: It included six different texts, used in primary school, and ranked in different levels of difficulty. Time is taken, and the numbers of words read in 1 min for each condition is calculated. Reading comprehension is assessed presenting direct questions about the texts.

2. *Reading words*: Three different lists, each containing 25 words, are used. The lists have different levels of difficulty. Time is measured.

Statistical Analyses

Means and standard deviations were calculated for the initial NEUROPSI scores. Pretest and posttest NEUROPSI scores were compared using ANOVAs with the Bonferroni correction. A $p < .05$ was considered statistically significant. Differences between the posttest and pretest scores were calculated, subtracting the initial test score from the final test score. Means and standard deviations in each group were calculated and ANOVAs comparisons were established using the Bonferroni correction. Mean and standard deviations

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were calculated in the reading tests. ANOVAs comparisons were established using the Bonferroni correction. Finally, Spearman's correlations between NEUROPSI (pretest and posttest) subtest scores and reading scores were calculated.

RESULTS

Two different types of analyses were performed: (1) NEUROPSI neuropsychological test battery scores before and after the learning-to-read training program were compared; and (2) performance in standard reading tests in the three groups at the end of the training period was analyzed.

Table 1 presents the initial scores in the NEUROPSI test battery and normative scores for illiterates. No significant differences among the three groups were found. Scores are similar to those reported for illiterate participants in the NEUROPSI neuropsychological test battery (Ostrosky et al., 1998, 1999). Table 2 presents the scores in the NEUROPSI after the training program. In general, an increase in the scores is observed. However, improvement is stronger in the first group (NEUROALFA method) than in the other two groups. Neuropsychological test performance in the experimental group is similar to that observed in individuals with 1 to 4 years of schooling (Ostrosky et al., 1998). Significant differences between the first (experimental) group and the two control groups are observed in 11 test scores, whereas in 13 test scores no significant differences across groups are found. Differences are noted in all battery domains, excepting Motor Functions. Strongest differences are found in Coding and Conceptual (executive) functions domains. Significant differences are observed in the following subtests: Orientation in Time, Digits Backward, Visual Detection, Verbal Memory, Copy of a Semi-Complex Figure, Language Comprehension, Phonological Verbal Fluency, Similarities, Calculation Abilities, Sequences, and all the recall subtests, excluding Recognition.

Differences between the pretest and posttest scores were calculated. Gains in scores between the two evaluations (be-

Table 1. Initial scores in the NEUROPSI neuropsychological test battery and normative scores for illiterates (Ostrosky et al., 1998)

	G1 (n = 21)	G2 (n = 21)	G3 (n = 18)			Normative
Subtests	M (SD)	M (SD)	M (SD)	F	p	scores
Orientation						
Time	1.95 (1.09)	2.40 (0.94)	1.25 (1.25)	0.13	.658	2.3 (0.8)
Place	1.86 (0.35)	1.95 (0.22)	2.00 (0.00)	2.37	.104	1.9 (0.2)
Person	1.00 (0.0)	0.22 (0.10)	1.00 (0.00)	0.67	.514	0.9 (0.1)
Attention						
Digits Backward	2.04 (1.09)	2.42 (1.14)	2.00 (1.15)	2.91	.091	2.4 (1.1)
Visual Detection	8.95 (4.15)	10.10 (3.75)	9.50 (4.35)	0.42	.653	9.9 (4.5)
20 Minus 3	1.86 (2.00)	2.25 (2.00)	1.00 (1.141)	0.71	.496	3.1 (1.9)
Coding						
Verbal Memory	4.36 (0.90)	4.25 (0.63)	3.75 (0.50)	1.07	.350	4.2 (0.6)
Copy of a Figure	8.20 (2.35)	8.05 (1.70)	7.00 (2.85)	0.53	.588	7.5 (2.0)
Language						
Naming	7.31 (1.05)	7.50 (0.76)	8.00 (0.00)	1.04	.360	7.3 (0.8)
Repetition	3.63 (0.49)	3.75 (0.44)	3.75 (0.50)	0.33	.719	3.8 (0.4)
Comprehension	3.18 (1.13)	3.80 (1.23)	3.50 (0.57)	1.49	.234	3.7 (1.2)
Verbal Fluency: Semantic	11.90 (3.66)	12.60 (3.08)	13.75 (3.50)	0.57	.567	13.5 (4.6)
Verbal Fluency: Phonol.	0.77 (1.84)	1.10 (1.58)	0.00 (0.00)	0.67	.470	3.1 (3.7)
Conceptual Functions						
Similarities	1.27 (1.83)	1.80 (2.21)	1.00 (0.81)	0.50	.605	2.1 (2.2)
Calculation Abilities	0.59 (0.85)	0.85 (1.13)	0.00 (0.00)	1.38	.261	0.9 (1.0)
Sequences	0.00 (0.00)	0.05 (0.22)	0.00 (0.00)	0.63	.532	0.1 (0.3)
Motor Functions						
Right-Hand Position	0.95 (0.65)	1.05 (0.68)	1.25 (0.50)	0.37	.690	1.1 (0.7)
Left-Hand Position	1.18 (0.66)	1.15 (0.74)	1.25 (0.50)	0.03	.963	1.0 (0.7)
Alternating Movements	0.86 (0.77)	1.10 (0.71)	0.75 (0.50)	0.71	.493	0.8 (0.7)
Opposite Reactions	1.95 (0.21)	1.75 (0.44)	2.00 (0.00)	2.34	.108	1.7 (0.5)
Recall						
Words	3.59 (2.19)	2.85 (2.34)	4.00 (0.41)	0.81	.449	3.1 (2.2)
Cuing	4.50 (1.33)	4.15 (1.30)	3.25 (0.95)	1.64	.205	4.1 (1.4)
Recognition	5.54 (1.10)	5.75 (0.71)	6.00 (0.00)	0.55	.579	5.4 (1.1)
Semi-Complex figure	6.45 (2.32)	7.20 (1.68)	5.75 (1.84)	1.19	.311	6.3 (2.2)

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Table 2. Final scores in the NEUROPSI neuropsychological test battery after the administration of the teaching-to-read program

	G1 (n = 21)	G2 (n = 21)	G (n = 18)			
Subtests	M (SD)	M (SD)	M (SD)	F	p	Differences
Orientation						
Time	2.68 (0.47)	2.45 (0.82)	1.25 (1.20)	6.63	.003	1,2 *vs.* 3
Place	2.00 (0.00)	1.95 (0.22)	2.00 (0.00)	0.63	.532	none
Person	1.00 (0.00)	0.95 (0.22)	1.00 (0.00)	0.63	.532	none
Attention						
Digits Backwards	2.86 (0.83)	2.65 (0.87)	1.50 (0.57)	4.48	.017	1,2 *vs.* 3
Visual Detection	12.5 (2.82)	9.75 (4.37)	8.50 (3.69)	4.08	.020	1 *vs.* 3
20 Minus 3	3.18 (1.94)	2.40 (1.95)	1.00 (1.14)	2.49	.090	none
Coding						
Verbal Memory	4.95 (1.48)	4.30 (0.65)	3.75 (0.50)	11.44	.001	1 *vs.* 2,3
Copy of a Figure	10.6 (1.09)	8.15 (1.82)	7.50 (2.27)	10.06	.003	1 *vs.* 2,3
Language						
Naming	7.90 (0.29)	7.65 (0.74)	8.00 (0.00)	1.51	.231	none
Repetition	3.90 (0.29)	3.75 (0.44)	4.00 (0.00)	1.41	.253	none
Comprehension	4.59 (0.90)	3.75 (1.16)	2.75 (0.95)	7.03	.002	1 *vs.* 3
Verbal Fluency: Semantic	13.0 (3.86)	12.90 (2.90)	14.50 (2.64)	0.38	.680	none
Verbal Fluency: Phonol.	8.04 (3.37)	2.05 (2.18)	2.75 (1.70)	25.28	.001	1 *vs.* 2,3
Conceptual Functions						
Similarities	4.69 (1.64)	2.00 (2.10)	1.25 (0.50)	13.55	.001	1 *vs.* 2,3
Calculation	2.00 (0.87)	1.20 (1.15)	0.75 (0.95)	4.62	.015	1 *vs.* 3
Sequences	0.63 (0.49)	0.05 (0.22)	0.00 (0.00)	14.47	.001	1 *vs.* 2,3
Motor Functions						
Left-Hand Position	1.36 (0.65)	1.15 (0.67)	1.50 (0.57)	0.79	.460	none
Right-Hand Position	1.50 (0.59)	1.30 (0.73)	1.25 (0.50)	0.59	.598	none
Alternating Mov	1.36 (0.78)	1.20 (0.61)	1.00 (0.00)	0.61	.613	none
Opposite Reactions	1.86 (0.35)	1.75 (0.44)	2.00 (0.00)	0.90	.410	none
Recall						
Words	5.00 (1.34)	3.00 (2.19)	3.50 (0.57)	6.42	.003	1 *vs.* 2,3
Cuing	5.45 (0.67)	4.25 (1.16)	3.50 (0.57)	13.16	.001	1 *vs.* 2,3
Recognition	6.00 (0.00)	6.00 (0.00)	6.00 (0.00)			none
Semi-Complex Figure	9.02 (1.40)	7.27 (1.67)	6.00 (1.68)	10.28	.002	1 *vs.* 2,3

fore and after the training program) were analyzed. Differences in the three groups are presented in Table 3. It is apparent that score gains were more robust in the first group. Gains were significantly higher in the first group in Orientation Time, Visual Detection, Verbal Memory, Copy of a Figure, Language Comprehension, Phonological Verbal Fluency, Similarities, Sequences, and all the recall subtests, excluding Recognition. No statistically significant differences between groups were observed in the other subtests.

Table 4 presents the scores of a standard reading test, designed to evaluate reading ability in first-graders. Reading speed was almost twice as fast in the first group compared with the two control groups. By the same token, reading comprehension was significantly superior in the NEUROALFA group. These differences were observed not only in the reading aloud condition but also in silent reading.

Correlations between reading ability and neuropsychological test performance were calculated for the pretest (Table 5) as for the posttest (Table 6) results. Correlations were established between NEUROPSI scores and reading ability scores in the total sample (N = 60), considering that the three groups were small. Correlations between initial scores and reading ability scores in general were low and statistically not significant. However, several correlations between posttest NEUROPSI scores and reading ability scores were found statistically significant. Highest correlations ($p < .001$) were found in the following subtests: Digits Backwards, Visual Detection, Verbal Memory, Copy of a Figure, Verbal Fluency (both conditions), Motor Functions: Right-Hand Position, Similarities, and Recall (cuing and Recognition).

DISCUSSION

Current results have significant implications to understand the effects of literacy. Learning to read reinforces certain fundamental abilities, such as verbal memory, phonological awareness, and visuospatial discrimination. It is not surpris-

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Table 3. Differences between the pre and post administration

	G1 (n = 21)		G2 (n = 21)		G3 (n = 18)				
Subtests	M	(SD)	M	(SD)	M	(SD)	F	p	Difference
Orientation									
Time	0.72	(0.98)	0.05	(0.22)	0.00	(0.00)	6.63	.003	1 *vs.* 2,3
Place	0.13	(0.35)	0.00	(0.00)	0.00	(0.00)	0.63	.532	none
Person	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)			none
Attention									
Digits Backwards	0.82	(1.40)	0.20	(0.69)	0.50	(0.57)	1.67	.199	none
Visual Detection	3.59	(4.48)	0.35	(0.98)	0.45	(0.20)	4.08	.021	1 *vs.* 2,3
20 Minus 3	1.31	(2.07)	0.15	(0.67)	0.00	(0.00)	2.49	.900	none
Coding									
Verbal Memory	0.59	(0.85)	0.05	(0.22)	0.00	(0.00)	4.58	.001	1 *vs.* 2,3
Copy of a Figure	1.86	(2.11)	0.10	(0.44)	0.50	(1.00)	7.15	.002	1 *vs.* 2,3
Language									
Naming	0.59	(0.95)	0.15	(0.36)	0.00	(0.00)	1.51	.231	none
Repetition	0.27	(0.63)	0.00	(0.00)	0.00	(0.00)	1.41	.253	none
Comprehension	1.40	(1.25)	0.05	(0.22)	0.00	(0.00)	7.03	.002	1 *vs.* 2,3
Verbal Fluency: Semantic	1.09	(2.84)	0.30	(1.34)	0.75	(1.50)	.66	.510	none
Verbal Fluency: Phonol.	7.27	(3.89)	0.95	(2.11)	2.75	(1.70)	25.28	.001	1 *vs.* 2,3
Conceptual Functions									
Similarities	3.36	(2.42)	0.20	(0.52)	0.25	(0.50)	19.04	.001	1 *vs.* 2,3
Calculation	1.40	(1.05)	0.35	(0.81)	0.75	(0.95)	4.62	.015	none
Sequences	0.63	(0.49)	0.00	(0.00)	0.00	(0.00)	14.47	.001	1 *vs.* 2,3
Motor Functions									
Left-Hand Position	0.40	(0.73)	0.10	(0.30)	0.25	(0.50)	1.55	.223	none
Right-Hand Position	0.31	(0.77)	0.00	(0.00)	0.00	(0.00)	1.45	.235	none
Alternating Mov	0.50	(1.05)	0.10	(0.30)	0.25	(0.50)	0.61	.546	none
Opposite Reactions	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)			none
Recall									
Words	1.40	(2.44)	0.25	(0.78)	0.05	(0.57)	3.13	.040	1 *vs.* 2,3
Cuing	0.95	(1.36)	0.10	(0.30)	0.25	(0.50)	4.13	.020	1 *vs.* 2
Recognition	0.45	(1.10)	0.25	(0.71)	0.00	(0.00)	0.55	.579	none
Semi-Complex Figure	2.56	(1.94)	0.07	(0.24)	0.25	(0.28)	18.63	.001	1 *vs.* 2,3

ing that illiterate people underscore in cognitive tests tapping these abilities. Furthermore, attending school also reinforces certain attitudes and values that may speed the learning process, such as the attitude that memorizing information is important, knowledge is highly valuable, learning is a stepwise process moving from the simpler to complex, etc. It has been emphasized that schooling improves an individual's ability to explain the basis of performance on cognitive tasks (Laboratory of Comparative Human Cognition, 1983). The fundamental aims of schools

Table 4. Mean scores and standard deviations obtained by the three groups in a reading test (Ostrosky et al., 1990)

	G1 (n = 21)		G2 (n = 21)		G3 (n = 18)			
Reading test	M	(SD)	M	(SD)	M	(SD)	F	p
Reading aloud								
Words/min	65.89	(11.55)	38.78	(6.58)	34.80	(5.30)	51.79	.001
Reading understanding (%)	86.36	(18.9)	67.14	(26.96)	60.01	(23.09)	4.68	.014
Silent reading								
Words/min	62.87	(11.42)	40.62	(5.78)	39.47	(3.81)	63.30	.001
Reading understanding (%)	89.09	(10.19)	66.01	(26.83)	60.01	(23.09)	8.35	.009

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Table 5. Spearman's correlations between initial scores in the NEUROPSI and reading ability scores. Total sample ($N = 60$)

	Reading understanding				Words/min			
	Oral		Silent		Oral		Silent	
Subtests	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Orientation								
Time	−.135	.304	−.144	.270	−.194	.136	−.240	.064
Place	−.177	.176	−.208	.111	−.209	.108	−.245	.058
Person	−.136	.299	−.156	.234	.057	.661	.060	.645
Attention								
Digits Backward	.006	.961	.009	.943	−.006	.960	.029	.824
Visual Detection	.118	.369	.102	.436	.104	.426	.167	.201
20 Minus 3	.243	.064	.197	.131	.023	.862	−.049	.705
Coding								
Verbal Memory	.097	.461	.073	.629	.044	.734	−.055	.753
Copy of a Figure	.192	.142	.185	.156	.272	.0350	.212	.103
Language								
Naming	.286	.026	.313	.150	.326	.011	.317	.013
Repetition	.284	.280	.281	.030	.247	.056	.206	.043
Comprehension	.205	.116	.271	.036	.181	.093	.262	.043
Verbal Fluency: Semantic	.035	.780	.103	.430	.175	.182	.211	.105
Verbal Fluency: Phonol	.136	.299	.283	.023	.136	.299	.171	.191
Conceptual Functions								
Similarities	−.096	.464	−.055	.674	.048	.715	−.052	.689
Calculation Abilities	.237	.062	.222	.082	.102	.437	.075	.566
Sequences	−.274	.022	−.301	.020	.117	.374	.126	.337
Motor Functions								
Right-Hand Position	.182	.163	−.154	.239	−.185	.156	−.221	.091
Left-Hand Position	−.043	.741	.023	.861	.003	.981	−.026	.844
Alternating Movements	−.067	.611	−.225	.083	−.036	.784	.111	−.844
Opposite Reactions	.048	.712	.071	.588	.083	.528	.104	.427
Recall								
Words	−.089	.494	.017	.183	−.128	.328	−.120	.359
Cuing	−.111	.401	−.262	.043	.064	.626	.035	.790
Recognition	−.314	.011	−.343	.007	−.266	.390	−.288	.251
Semi-Complex Figure	.106	.142	.185	.156	.272	.035	.212	.103

are equivalent for all schools and school reinforces certain specific values regardless of where they are located. Hence, school could be seen as a culture unto itself, a transnational culture, the culture of school. School not only teaches, but also helps in developing certain attitudes that will be useful for future new learnings. Ciborowski (1979) observed that schooled and nonschooled children can learn a new rule equally well, but once it has been acquired, schooled children tend to apply it more frequently in subsequent similar cases.

NEUROALFA was developed as a learning-to-read method in which these fundamental abilities and these attitudes were not just tangentially considered, but directly targeted. Special exercises were developed to reinforce these fundamental abilities. For example, combining sounds to form new words, finding phonological and semantic similarities between words, memorizing the information that is read, analyzing proverbs to emphasize that the language has different levels of meaning, and emphasizing the visual discrimination of letters, and upper- *versus* lower-case letters. A positive attitude for learning was reinforced most successfully using strategies such as departing from purely personal and family issues, emphasizing that learning to read is important for understanding a medical prescription, and having access to booklets dealing with health issues. Reading the newspaper is crucial to knowing and understanding better the surrounding world, etc.

Current results support the assumption that direct training and reinforcement of those abilities in which illiterates significantly underperform will result in a significant improvement in neuropsychological test scores. Improvement was observed in various cognitive domains, but especially in visuoconstructive ability (Copying a Semi-Complex Figure); Phonemic Verbal Fluency; finding similarities (Similarities subtest); and language understanding (Language Comprehension subtest). In some domains, however, no significant improvement was observed (Motor Function subtests).

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Table 6. Spearman's correlations between final scores in the NEUROPSI and reading ability scores. Total sample ($N = 60$)

	Reading understanding				Words/min			
	Oral		Silent		Oral		Silent	
Subtests	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Orientation								
Time	.302	.019	.207	.112	.286	.021	.314	.001
Place	−.097	.461	−.103	.433	−.102	.436	−.222	.085
Person	−.125	.260	−.132	.277	−.157	.632	−.217	.096
Attention								
Digits Backward	.522	.000	.437	.000	.728	.000	.712	.000
Visual Detection	.603	.000	.533	.000	.862	.000	.806	.000
20 Minus 3	.356	.005	.374	.003	.197	.131	.184	.159
Coding								
Verbal Memory	.639	.000	.534	.000	.728	.000	.629	.000
Copy of a Figure	.601	.000	.507	.000	.853	.000	.803	.000
Language								
Naming	.231	.075	.238	.066	.301	.020	.176	.178
Repetition	.252	.062	.284	.093	.210	.103	.114	.280
Comprehension	.269	.370	.197	.131	.464	.000	.521	.000
Verbal Fluency: Semantic	.571	.000	.501	.000	.801	.000	.762	.000
Verbal Fluency: Phonol	.574	.000	.542	.000	.811	.000	.783	.000
Conceptual Functions								
Similarities	.491	.000	.463	.000	.688	.000	.649	.000
Calculation Abilities	.058	.655	.225	.083	.181	.165	.132	.314
Sequences	.003	.982	.037	.744	.121	.358	.031	.813
Motor Functions								
Right-Hand Position	.492	.000	.428	.000	.711	.000	.682	.000
Left-Hand Position	.007	.957	.052	.690	.028	.829	.021	.876
Alternating Movements	.343	.000	.257	.041	.405	.001	.421	.001
Opposite Reactions	.396	.002	.266	.041	.598	.000	.522	.000
Recall								
Words	.156	.233	.108	.407	.264	.034	.316	.001
Cuing	.622	.000	.551	.000	.861	.000	.802	.000
Recognition	.605	.000	.533	.000	.865	.000	.813	.000
Semi-Complex Figure	.616	.000	.513	.000	.853	.000	.797	.000

All the three learning-to-read methods resulted in some improvement in neuropsychological test performance. Improvements in scores were potentially the result of two different factors: (1) retesting and (2) training program. Of course, other uncontrolled variables might be involved, even though it is unlikely they could have a significant impact on the results. What was really surprising was the mild improvement or no improvement observed in several subtests in the two control groups. We suspect that this poor cognitive test performance improvement is highly correlated with the above-mentioned observation that only 28.63% of the adult students attending the traditional INEA programs successfully learn to read.

It is important to emphasize that observed differences among groups are also in some extent related to teaching time. The Express method is considerably shorter, and evidently final reading performance in this group was very low. However, NEEBA and NEUROALFA require a similar amount of time (about 40 hr, plus the exercises). In consequence, the really valid comparison that can be established is between the NEUROALFA and NEEBA methods.

The most crucial step in teaching an adult to read is making sure that the student really understands how the writing system works and gets personally involved in the process. A significant introductory process and deep personal involvement are required. In the NEUROALFA method the two first teaching topics are (1) to emphasize as much as possible that reading is most important in everyday life, and any significant information can be represented in writing; furthermore, written language is similar to and parallels spoken language; and (2) to teach the student to read his or her own name. To recognize how our own name is written is a very exciting experience for everyone. For all of us it is very exciting to find out how our name is written in a different writing system, for instance Chinese characters, and to understand how different lines and symbols correspond to different parts of the name. A similar excitement is observed in the illiterate when first understanding how his or her name

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is written on IDs, on the class roster, on the blackboard, etc., and to discover the strategies used in representing the name. The following step in the NEUROALFA is the analysis of the proper name into the sounds that form it, and further creating new words using the proper name letters. This is really the first step to understand how the writing system works. If this initial process fails, the whole learning-to-read process will fail.

Notably, significant improvement was observed in some subtests that were not directly targeted during the learning-to-read program. This was true with regard to Orientation in Time, Calculation, and Sequences subtests. As a matter of fact, all these three abilities can be partially interpreted as executive function abilities. It may be conjectured that the strategies reinforced when analyzing and understanding the reading system require the application of some metacognitive principles (e.g., using analytic strategies, planning, organizing output sequences, etc.). These metacognitive principles become available to be applied to some other tasks. For instance, for successfully deducing what figure continues a sequence (Sequences subtest).

To separate the effects of literacy from the effects of school is not easy. School not only teaches but also reinforces some attitudes and values. During the development of the NEUROALFA program these school-based values were emphasized as much as possible: to memorize, to make practical use of reading in the everyday life, etc. Scribner and Cole (1981) attempted to separate the effects of literacy from the school effect. Among the Vai people in Liberia they found some individuals who were literate in the Vai script but who had not attended formal schools. Using a battery of cognitive tests they found that there were no general cognitive effects of literacy, but there were some specific test performances that were related to the particular features of the Vai script. They concluded that literacy makes some differences to some skills in some contexts. Berry and Bennet (1989) carried out a partial replication of this study among the Cree of Northern Ontario. Our results partially corroborate Scribner and Cole's results. Notably, improvement in neuropsychological test performance was quite limited in our G2 and G3. G3, however, significantly improved in the Phonological Verbal Fluency test, which was most likely related to the phonological approach used in the Express Method.

It should be emphasized that in both the Global Method (NEEBA; G2) and Express Method (G3), the emphasis is placed in learning to read, not in learning to write. In fact, the Express Method does not include writing at all. In the NEEBA method even though writing is included, emphasis is placed in reading, not in writing. This was a major difference with the NEUROALFA method that potentially may account for some differences observed in test performance among the three groups. In Scribner and Cole as well as the Berry and Bennet studies mentioned above, this also was a potentially confounding factor. Learning to write requires the use of significant graphomotor and visuospatial abilities that are not crucial for reading and are not reinforced in just learning to read.

It is important to emphasize that correlations between pretest scores and reading ability scores were in general low and not significant. However, correlations between posttest NEUROPSI scores and reading ability scores were significant in several subtests. This observation supports the assumption that neuropsychological test scores indeed do not exactly predict learning to read scores, but learning to read reinforces those abilities required to obtaining a high performance in neuropsychological tests. This observation may be most important in the cognitive testing domain and in the analysis of the relationship between education and cognitive test performance.

Though it is well established that there a significant correlation between cognitive test scores (e.g., IQ) and school attendance interpreting this correlation has been problematic (Brody, 1992; Neisser et al., 1996). The really crucial question is: Do cognitive (intelligence) tests indeed predict school performance? Or rather, does school train those abilities appraised in intelligence tests? To answer these questions is not easy, even though frequently the interpretation has been that IQ predicts school performance (e.g., Hunter, 1986). Other researchers, however, consider that IQ scores are to a significant extent a measure of direct and indirect school learning (e.g., Ardila, 1999; Ceci, 1990).

Ceci (1991) presented an extensive and detailed review of available data in this area. The general conclusion is that school attendance accounts not only for a substantial portion of variance in children's IQ but also apparently some, though not all, of the cognitive processes that underpin successful performance in IQ tests. The magnitude of this influence ranges from 0.25 to 6 IQ points per year of school. In consequence, the association between IQ and education cannot be interpreted assuming that IQ predicts school success. Intelligence and schooling have complex bidirectional relationships, each one inducing variations in the other (Ceci & Williams, 1997). According to our results, even though bidirectional relationships may exist, the really significant relationship is between schooling (in our case, learning to read) and cognitive test performance. That is, learning to read significantly impacts cognitive test performance.

For English speakers it can be surprising the short time required learning to read the Spanish language. It is important to note that Spanish possesses a phonologically transparent reading system, and a less transparent writing system. Ambiguity in its reading writing system goes only in one direction: many words potentially can be written in different ways. In other words, in Spanish, homophonic heterography can be found (e.g., *ha* and *a* are both read as /a/), whereas homographic heterophony is absent. That is, any word or pseudoword can be read in only one way: there are not alternative readings for any string of letters. As a result of the simplicity of the Spanish reading system, usually children can learn to read during the first grade. First-grade reading books usually begin reviewing the sounds of the different letters. The letters 'M,' 'P,' and 'S' (in that order) are initially presented and simple words (e.g., *mamá*, *mapa*) and

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short phrases (e.g., *Mi mamá puso mi sopa*) are introduced. Further, they introduce complex syllable combinations (e.g., 'PR,' 'BL') and longer sentences (e.g., *Tu profesor te prepara para la vida*). Finally, reading short paragraphs and one-to-two page stories are presented (e.g., Grupo de Asesoría Didáctica, 1984). During the first grade it is expected that children will also learn to write any word without "nonhomophone" errors (additions, omissions of substitutions of letters that in that particular position result in an erroneous phonographemic conversion), but not without "homophone" or "orthographic" errors (additions, omissions or substitutions of letters that in that particular position do not result in erroneous phonographemic conversion). To teach adults to read is usually accomplished in 1 year or less. As a matter of fact, INEA traditional programs take about 20 to 50 hr of direct training plus, of course, significant additional homework.

Wesuppose that directly targeting and emphasizing some weak abilities (e.g., phonological awareness) required to read will speed the learning to read process. We further suppose that writing may require some additional abilities (e.g., spatial) so crucial for reading. In our study G3 (Express) had a shorter training time, and comparisons between G1 (NEUROALFA) and G2 (NEEBA) are seriously biased by this time factor. Learning time, however, was equivalent between G1 (NEUROALFA) and G2 (NEEBA). The NEEBA method also includes some writing. It can be conjectured that the NEUROALFA method was better at targeting these abilities required for reading.

Finally, it is interesting to mention that the NEUROALFA method has been accepted as the best teaching-to-read adult program in Colima State (Mexico). Currently, they are beginning to use it extensively. It is likely that in the near future the NEUROALFA method will be adopted by the INEA as the official method to teach adults to read in the Mexican Republic. To our best knowledge, this would be the first extensive application of neuropsychological principles to approach social problems.

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Appendix 1

GENERAL STRUCTURE OF THE NEEBA METHOD

Lesson	Objective	Strategies	Target
1–10	To recognize some characteristics of written language.	To explore different materials.	To get a basic reading.
	To identify their own name.	Own name in different materials.	
	To identify different words.	Guided reading: popular tales.	
		Recognition of upper and lower case.	
	To identify important news.	Identifying and writing words and short sentences.	
		Reading the words in the calendar.	
		Reading instructions.	
11–25	To increase the words that can be recognized.	Reading and writing public services.	To improve reading and writing.
		To compare oral and written words.	
		Recognizing and writing short texts.	
	To find information of social interest.	To find new words.	
		Description of common logotypes.	
		Identifying masculine and feminine words.	
	To interpret information in written materials.	To find information in a national map.	
		Identification of songs.	
		Composition of letters and messages.	
26–35	To improve reading.	Reading and writing brief texts.	To improve reading and writing.
		Recognition of interrogative sentences.	
		Preparing different types of letters.	
	To practice reading comprehension.	To create a story from a picture.	
		Autobiography.	
		Synonyms.	
		Writing brief texts.	
36–46	To improve reading ability.	Reading about everyday situations.	Reading understanding.
		Newspapers.	

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Appendix 2

GENERAL STRUCTURE OF THE NEUROALFA METHOD

Lesson Objective	Strategies	Target
PART I		
1. To demonstrate how important it is to read in everyday life.	To present, analyze, discuss participant's ID, names of streets, medical prescriptions, songs, labels in institutions.	To demonstrate the importance of reading in personal life.
2. To recognize the letters of one's own name and of the letter sounds included in the name. To combine these letters.	Phonological discrimination.	To be able to read some words.
3. To read and write letters, corresponding to other family members.	To form new words. To group words according to phonological similarity.	To write and read some words.
4. To read and write the whole names of family members.	Visual discrimination of letters. Visual recognition of words. Decomposition of words into letters. To form new words using the letters of family members' names.	To be able to read sentences and to recall them.
5. To recognize and use the letters of family members' names.	Visual discrimination of words. Reading and copying words: semantic associations of the words. To group words having three common phonemes. Upper-case and lower-case letters and their use.	To read and to create a text about the family. To use spatial orientation of letters. Using the distribution of words.
6. To read about home activities.	Names of home elements and activities. Crosswords: analysis of phonemes. Write about home activities.	To read and create a text about home activities.
7. Identification of the whole alphabet.	Identification of new letters. Reading traffic signals. Proverbs. Analyzing the meaning of proverbs.	To read and write the whole alphabet.
PART II		
1, 2, and 3. Applications of reading and writing.	Messages, letters, IDs, receipts, immunization booklet. Reading and writing text regarding health, reading and commenting on the newspaper, etc.	To actively use reading and writing. To recall written texts.

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