Neuropsychological Aspects of Illiteracy

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The study of subjects who never learn the written representation of language is important because it allows us (1) to understand how oral language processing can be modified through learning a grapheme–phoneme matching operation, (2) to understand if different areas of the brain are involved in the processing of oral language when comparing literate and illiterate subjects, (3) to identify adequate neuropsychological instruments to assess cognitive dysfunction due to brain lesions in poorly educated persons, and (4) to study possible alternative cognitive strategies spontaneously developed by illiterate subjects that may be useful for rehabilitation.

Results from the literature are reviewed and new data from our current research in this field are reported.

INTRODUCTION

The modulation of individual cognitive strategies as a result of learning is still poorly understood and open to discussion.

Indeed, the first question concerns the way learning modulates strategies of cognition and the possible influence of these new learned strategies for subjects’ performance in other cognitive areas. In other words, if one learns a new skill one certainly develops a strategy; the question is if (or by what means) this new strategy influences the functional organisation of previously acquired cognitive processing. The second question concerns the relationship of these processes with the functional organisation of the brain. By functional organisation of the brain we mean the areas involved in the processing of information. Finally, it is important to know how to deal with these aspects in designing tests and in scoring responses in the field of neuropsychology.

Illiteracy constitutes a good example in discussing these topics, provided that we use a correct definition of the population of illiterate subjects. It has been recognised all over the world that a significant number of individuals after
their normal period of schooling in childhood, and thus, after having learned how to read and write, become functional illiterates in adulthood. This is due to the loss of reading practice. This population has to be distinguished from the one composed of subjects who, for social reasons, never attended school in their lives. These are the real illiterate subjects who were never exposed to the experience of a symbolic written representation. They never learned a grapheme–phoneme matching operation. Going back to the general problem, it is important to understand how the lack of this skill may influence the way illiterate subjects deal with oral language and other aspects of related behaviour.

In this paper we will review studies concerning (1) language processing by illiterate subjects without brain lesions in order to understand how oral language processing can be modified through learning a grapheme–phoneme matching operation, (2) the hypothesis of a different mapping of neural structures involved in language processing by illiterate compared to literate subjects (that is, functional cerebral organisation), and (3) the influence of illiteracy on some other abilities related to language in order to identify problems encountered in test selection and scoring.

ILLITERACY AND ORAL LANGUAGE OF NON BRAIN-DAMAGED SUBJECTS

One of the interesting questions related to language processing concerns the problem of segmentation. Segmentation is important in obtaining meaningful units that are useful for both auditory comprehension and oral production of language. A word is a sequence of sounds that has to be decoded and a sequence of movements that has to be produced. Meaning is extracted by analysing the sequence of components of the word and by confronting the result with previously learned sequences. This goal can be reached through meticulous analysis of the sequences and components. However, meaning can also be obtained through global perception of the word. The first mechanism depends on the phonological system, the second may be the result of contextual circumstances or the result of the analysis of other qualities of oral communication such as prosody or melodic intonation.

Morais and colleagues (Morais, 1993; Morais, Berteleson, Cary, & Alegria, 1986; Morais, Cary, Alegria, & Bertelson, 1979; Morais et al., 1988) reported that the awareness of the phonological system and of phonemic representations does not arise spontaneously and is dependent on learning to read and write. In their studies they demonstrated that illiterate subjects behaved differently on tasks such as initial consonant deletion that required explicit phonological and phonemic analysis.

If one talks to illiterate subjects, no language deficits are apparent. By simply analysing their spontaneous speech production or comprehension it is impos-
sible to know about their reading and writing skills. We can thus assume that they are skilled in carrying out phonological analysis. However, it is possible to create conditions in which the subject is forced to use this system, like, for instance, in repetition tasks of words and nonwords.

Adrián (1993) studied this problem in populations of different educational backgrounds and concluded that the capacity to use the phonological system was reduced in illiterate subjects. The author used a set of tests in which the subjects were asked to match words according to their morphology (rhyme, consonant disparity, etc.). Illiterate subjects performed significantly worse than literate subjects in tasks that required a more detailed analysis of the word and were even poorer when the segments of the nonwords used were less familiar. Similar findings were reported in South American subjects (Ardila, Rosselli, & Rosas, 1989; Rosselli, Ardila, & Rosas, 1990). The authors studied extreme groups with respect to education and found that the results of the phonological discrimination tasks varied according to educational level and age—the interaction between these two variables was also significant.

With these results in mind we designed a test of word repetition composed of 24 high frequency words and 24 nonwords which were identical in length and number of syllables (all the groups of vowels were maintained; the groups of consonants were all changed in a way that the neologisms were plausible). Subjects were instructed to repeat all the words as they heard them bearing in mind that there were nonwords in the series. The 48 words and nonwords were presented randomly to 24 illiterate subjects and 17 literate subjects. The two groups were comparable with respect to age and socio-cultural background. The results showed that repetition of nonwords was very poor in the illiterate group and that these subjects had a tendency to transform the nonwords into meaningful words (Reis & Castro-Caldas, 1995).

The performance of illiterate subjects in this task revealed a poor capacity for segmental analysis and a tendency to process the meaning of the word rather than its form. This calls attention to the possibility that illiterate subjects prefer to process language through semantics rather than through morphology.

A second test was designed to examine this hypothesis. Using the word pair association paradigm of the Wechsler Memory Scale we prepared two sets of 10 pairs of words. In the first set the words were morphologically related (for example, “mala–pala” or “lua–rua” and in the second set the words were semantically related (for example, “garfo–colher” which means “fork–spoon” or “rosa–cravo” which means “rose–carnation”). Five pairs of each set were randomly combined in two sets of 10 pairs each. The instructions and the method of administration were similar to the original test (Wechsler, 1969). The two tasks were presented to the same group of 24 illiterate and 17 literate subjects. Results showed that illiterate subjects performed worse than literate subjects on recalling morphologically related words (Reis & Castro-Caldas, 1995). Error analysis for the illiterate subjects showed a tendency to produce
semantically related associations when morphologically related responses had to be given.

The results of these experiments allow the conclusion that illiterate subjects show poor performance in tasks requiring morphological analysis of words. This may reflect different strategies of language processing by illiterate subjects. These different strategies have to be taken into consideration when studying aphasic subjects. Language tests in which the morphology of the word is important must be avoided such as, for instance, in tests of verbal fluency with formal criteria. In these tests the errors produced by illiterate aphasics may be erroneously interpreted as a reflex of aphasia when in fact they simply represent the normal use of language. On the other hand these aspects, which were used as examples, are important for planning rehabilitation as we will see later. Finally, we should consider that the use of different strategies may reflect the involvement of different areas of the brain.

ILLITERACY AND THE CEREBRAL REPRESENTATION OF LANGUAGE MECHANISMS

Lecours extensively reviewed the literature concerning aphasia in illiterate subjects (Lecours et al., 1987a, b, 1988). Before 1970, the existing information consisted of personal opinions and anecdotal evidence. Most of the authors suggested that aphasia tended to be less severe and more transient in illiterate persons. Therefore, it was suggested that the right hemisphere is involved in language processing in illiterate subjects.

However, pioneers of aphasiology in the early 19th century suggested by virtue of clinico-anatomical correlations, that the left hemisphere was dominant for language. In those days, literacy was reserved for the higher social classes and post-mortem studies were performed mostly in indigent people. It is thus conceivable that most of the evidence concerning cerebral dominance was based on the study of illiterate patients. To our knowledge no one knows, for instance, whether the patient Leborgne studied by Broca was illiterate or not.

In 1971, Cameron, Currier, and Haerer published a report reviewing the cases of 62 right-handed and three left-handed adults with right hemiparesis or hemiplegia resulting from a left sylvian stroke. Thirty-seven subjects were said to be literate, 14 semi-literate and 14 illiterate. They found transitory or persistent aphasia in 78% of the literate subjects, 64% of the semi-literate subjects and in only 36% of the illiterate subjects. It is important to note that the group considered as illiterate had an average of 2.5 years of schooling which may not reflect illiteracy for social reasons but illiteracy due to learning disabilities. As we have stressed before, the correct definition of the population studied is crucial for valid results. In this particular case of clinico-anatomical correlations it is important to rule out the hypothesis of a particular type of brain organisation which may be responsible for the learning difficulties. Previous
cultural experience is as important as previous biological experience of the brain (Guerreiro, Castro-Caldas, & Martins, 1995).

The second study was performed in Portugal (Damásio, Castro-Caldas, Grosso, & Ferro, 1976a, Damásio et al., 1976b) and the results are summarised in Table 1. This study contradicts the findings of Cameron et al. (1971). As a matter of fact, the number of cases with aphasic symptoms due to left hemisphere lesions is similar in literate and illiterate subjects. On the other hand, if the right hemisphere contributes more to language processing in illiterate persons one should expect a high number of illiterate crossed aphasics. This finding was not confirmed by our experience (Castro-Caldas & Confraria, 1984).

It may be concluded, therefore, that there is no evidence of a less lateralised language representation in illiterate subjects. Furthermore, we still do not know if the areas involved in language processing in the left hemisphere are the same as the ones reported for literate subjects. Our preliminary studies in Wernicke’s aphasia suggest that the localisation and extension of lesions are comparable to what concerns the involvement of the classical language areas (Parreira et al., 1995). However, this study was carried out on stroke patients and measuring the extension of the lesion in these cases may be measuring the vascular territory of an artery, which is certainly not related to literacy.

Some studies with dichotic listening were conducted in illiterate populations. This technique may also contribute to the study of cerebral dominance for language and thus to understanding the possible role of the right hemisphere in language processing. Tzavaras, Kaprinis, and Gatzoyas (1981), using pairs of digits, suggested that illiterate subjects showed a greater right ear advantage than educated control subjects. The authors claimed that “the acquisition of reading and writing skills results in an ambi-hemispheric representation of strategies (mechanisms) for the solution of some language problems”. In a recent study, Tzavaras, Phocas, Kaprinis, and Gatzoyas (1993) studied the same question again with functionally illiterate men and the results were in accordance with the previous conclusion.

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<th>TABLE 1 Evaluation of 225 Right-handed Focal Brain-damaged Patients</th>
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<td><strong>No. (%) of patients with</strong></td>
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<td>Literate (182)</td>
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<td>Illiterate (43)</td>
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From Damásio et al., 1976b
Damasio, Damasio, Castro-Caldas, and de S. Hamsher (1979) administered a dichotic listening task consisting of pairs of phonetically “similar” meaningful words (differing in one consonant phoneme only) to literate and illiterate subjects. Results showed that illiterate subjects failed to show a right ear advantage in this task contrary to literate subjects who showed the usual pattern of ear advantage. On the other hand no differences were found between groups when markedly “dissimilar” words were used: All subjects showed the classical right ear advantage.

These results were contradicted by Castro (1992) to some extent, who found no differences in dichotic listening performance in relation to cultural background.

On the basis of the existing information about brain-lesioned patients and dichotic listening studies, it seems difficult to find a clear influence of right hemisphere mechanisms on language processing in illiterate subjects. This does not imply, however, that on certain occasions and for certain tasks they prefer to use “right hemisphere strategies”.

Analysis of the different symptoms that are generally considered for the clinical classification of aphasia type may also contribute to finding and understanding possible differences. Taking into consideration the four core symptoms that in our laboratory are used for classification according to aphasia type (speech fluency, visual naming, oral comprehension, and word repetition) (Ferro, Santos, Castro-Caldas, & Mariano, 1980), we reviewed the diagnosis of 1358 left hemisphere stroke aphasic patients of different cultural backgrounds. The results showed that if we considered the classical diagnosis of global, Broca’s, Wernicke’s, conduction, anomic, and transcortical aphasia, the distribution was statistically similar in all educational groups considered (Castro-Caldas et al. 1995). A more detailed analysis of a small group of patients revealed, however, that some differences could be detected. As a matter of fact, word repetition is more disturbed in illiterate subjects than in literate ones in Wernicke’s aphasia (Castro-Caldas, Reis, & Parreira, 1994). This seems to reflect the previously mentioned difficulty of illiterate subjects to deal with morphological aspects of language. If these subjects, before becoming aphasic, had difficulties in dealing with the segmentation process, they will certainly have greater difficulty in repeating words which they do not comprehend. These words are processed as nonwords by these aphasic patients.

Concerning other aspects of aphasia it is important to keep in mind the results reported by Lecours et al. (1987a, 1988). These authors reported a more serious impairment in visual naming in illiterate subjects. This was found in the control group without brain lesion, in aphasic patients with left hemisphere lesions and in nonaphasic patients with right hemisphere lesions. The authors concluded that the “cerebral representation of language is more ambilateral in illiterate than it is in school educated subjects, although left cerebral ‘dominance’ remains the rule in both” (1988, p. 575).
There are several reports in the literature addressing the topic of cultural influences in neuropsychology testing. Garcia and Guerreiro (1983) showed that illiterate subjects without brain disease scored below their literate controls in subtests of the Wechsler Memory Scale, in a questionnaire for daily life events, in Raven’s Coloured Matrices and in block design (WAIS). Ostrosky-Solis et al. (1985, 1986) presented a neuropsychological diagnostic battery to 109 normal subjects from two sociocultural levels and found that the most sensitive items were those that involved the use of complex conceptual aspects of language and the organisation of motor sequences and motor programmes in general. Ardila et al. (1989) and Rosselli et al. (1990) reported the results of a large test battery administered to extreme educational groups (non brain-lesioned illiterates and professionals). The test battery included visuospatial, memory, language, and praxic abilities. There were differences in most of the subtests related to educational level. We will focus firstly on their results for tests that involved language skills: (1) Language comprehension tasks showed differences with respect to educational level—most differences were found in complex (i.e. the three paper test) and semicomplex commands (i.e. put the cigarettes above the matches). (2) phonologic discrimination tasks showed differences according to educational level and age—the interaction between them was also significant; (3) naming real objects was only slightly different between educational groups—only some low education subjects presented a few mistakes (naming “bracelet”, which none of them used); (4) naming figures was highly dependent on educational level—the older low education group presented the highest number of errors; (5) naming body parts presented a robust educational effect particularly in finger naming; (6) in word repetition the number of errors was significantly increased in the low educational group; (7) verbal fluency, which was tested giving phonological or semantic cues, showed significant differences in both subtests for educational level—the difference was much higher for the phonological subtests. In visuospatial tasks (figure copy, telling time, recognition of superimposed figures, recognition of a map, and drawing of the plan of the room) significant differences between literate and illiterate subjects were present as well. In memory tasks, with the exception of the immediate memory of sentences, all tasks showed statistically significant differences between educational groups. The other tests of memory were: basic information, digit span (forwards and backwards), memory curve (number of presentations necessary to learn a sequence of 10 words), delayed verbal recall, logical memory, delayed logical memory, immediate recall of the Rey-Osterrieth complex figure, immediate reproduction of a cube, visuospatial memory, and sequential memory.
These results raise the problem of the adequacy of the tools generally used in neuropsychological testing for poorly educated patients. For some of the tests, norms and correction scores are available. This was the case, for instance, for our version of the Token Test; there were consistently low scores among the normal controls that were used for standardisation (Castro-Caldas, 1980). In other cases the standardisation revealed the absence of consistency among controls, suggesting that the ability for which the test was addressed varied according to individual experience. This was the case, for example, for visual naming of drawings.

The influence of educational level on naming tasks was stressed by Borod, Goodglass, and Kaplan (1980) and Kremin, Deloche, and Metz-Lutz (1991). As we mentioned above, Lecours et al. (1987a, 1988) and Rosselli et al. (1990) found that this task was difficult for illiterate subjects. The results we obtained in our laboratory with the visual naming of drawings subtest from the Multilingual Aphasia Battery illustrate this aspect. In this test, the subjects are asked to name 41 line drawings of objects. The major problem was the great variability of the individual scores which prevented the normalisation of the test for illiterate subjects. This variability was interpreted on the basis of the individual experience of the subjects and, perhaps, on their own skills for visual analysis.

Based on these results we recently designed a study in which performance in naming real objects was compared to performance in naming photographs and drawings of these objects. The test was presented to three groups of non brain-damaged individuals with different levels of education (illiterate, < 4 years of schooling and > 4 years of schooling). Results showed that there was a clear influence of educational level. Naming photographs was difficult for illiterate subjects although not as difficult as naming drawings (Reis, Guerreiro, & Castro-Caldas, 1994). Our conclusion is that naming drawings must be avoided in constructing aphasia test batteries that are to be used in poorly educated subjects. It is not easy to understand fully the reason for these findings. Differences in visual scanning have been found in poorly educated subjects when compared to higher educated subjects (Ostrosky-Solis, Efron, & Yund, 1991). However, we do not think that an explanation as simple as that is sufficient. The lack of experience to deal with the two-dimensional space through hand drawing is certainly important to understand the meaning of the figures (Deregowski, 1986).

Another area that needs more detailed study concerns calculation. There are illiterate subjects who show remarkable expertise in mental calculation but this is not the rule. The need to deal with numbers and calculation tasks in daily life requires these subjects to generate strategies of their own. We were particularly impressed by the digit representations of one woman (Fig. 1). She was able to make a list of telephone numbers using drawings to identify the person or the place and a system of her own involving the representation of the quantity for each digit.
We confronted this finding with previously obtained results on digit span tasks. Illiterate subjects performed worse than their literate controls. This leads to the hypothesis that illiterate subjects have to memorise the quantity itself and not its symbolic representation. A digit span task was designed to examine this hypothesis. The task consisted of two different sets of digit sequences. In the first, only the digits 1–5 were used, the second included digits 5–9. Results showed that for literate subjects the two sets were equivalent but this was not true for illiterate subjects who performed more poorly on the second set. These results are in accordance with the above mentioned hypothesis (Reis, Guerreiro, Garcia, & Castro-Caldas, 1995).

A final study deserves mention. Ferro, Castro-Caldas, Martins, and Salgado (1981) reported on three-dimensional constructional apraxia in aphasics comparing literate and illiterate subjects based on the analysis of the results obtained in the test for three-dimensional apraxia of Benton (Benton & Fogel, 1962). The incidence of constructional apraxia was similar in literate and illiterate subjects in the groups of right hemisphere lesions (stroke and tumours) and in patients with left hemisphere lesions without aphasia (stroke and tumours). However, constructional apraxia was much more frequent in illiterate subjects in the group of left hemisphere lesions with aphasia (both in stroke and in tumour cases). Our interpretation for these findings was that the strategy for the execution of the models was mediated by language. Illiterate, non brain-lesioned subjects tended to be more talkative during the execution of the models. Aphasia was, thus, probably responsible for their lower performance.

FIG. 1   Representation of telephone numbers by an illiterate woman. The drawing identifies the owner (the daughter is identified as a sun because she is "the sun of her life").
Another possible explanation is based on the hypothesis that the acquisition of reading and writing skills occupies left temporoparietal areas. This would force the right-sided areas to be involved in constructional abilities in literate subjects. According to this hypothesis illiterate subjects would use mainly the left hemisphere for constructional praxis whereas literate subjects would prefer right hemisphere strategies. This interpretation is challenged by the finding of similar performances in literate and illiterate subjects with right hemisphere lesions because one would expect to have less constructional apraxia in right hemisphere lesioned illiterates. We have to admit that in illiterate persons both hemispheres contribute to solve the problems raised by three-dimensional construction, probably using different strategies.

Finally, a word must be said about recovery of function and techniques for rehabilitation. Concerning recovery aspects, we can conclude, on the basis of our own data, that the outcome of global aphasia at six months post stroke is the same in literate and illiterate aphasics. It is also important to note that the positive influence we found for speech therapy is present in both groups of subjects. Techniques used in speech therapy are somewhat different. Line drawings cannot be used, real objects are used instead. Abstract situations are substituted by concrete ones (Leal et al., in preparation).

CONCLUSION

Although it is still necessary to obtain more information about the topic of illiteracy, three aspects can be stressed for the moment. (1) There are findings that suggest that some processing strategies of oral language are different in illiterate when compared to literate subjects. (2) There are results suggesting that the use of some tests for aphasia must be avoided in illiterate populations due to the lack of validity. (3) The study of cognitive strategies of illiterate subjects may contribute to the design of rehabilitation techniques for literate subjects exploring alternatives for cognitive processing.

REFERENCES


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