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Does literacy have an effect on stick construction tasks?

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Abstract

Since constructional apraxia is often concomitant with brain lesions, the study of constructional tasks in the non-brain-damaged population might be useful in helping to disentangle other causal factors. This paper explores the performance of illiterate individuals ($N = 29$) as compared to that of semiliterates ($N = 21$) and literates ($N = 23$) in order to see the effect of reading and writing abilities on constructional tasks. Each participant was asked to construct 4 figures based upon models having varying degrees of complexity. A global criterion of lack of fidelity and several analytic criteria (related to distortion, rotation, and disarticulation errors) were used to evaluate performance. Although illiterates generally made more errors than semiliterates and semiliterates more than literates, only some of these differences were statistically significant. Significant differences were found for lack of global fidelity and disarticulation errors when all 4 figures were considered together. Subtler data emerged with respect to single figures. (*JINS*, 2000, *6*, 668–672.)

Keywords: Illiteracy, Constructional tasks, Assessment, Praxias, Cross-cultural

INTRODUCTION

Nearly half of the world population is illiterate. During the second half of the 19th century the possible relevance of illiteracy to functional brain organization was first hypothesized (Scoresby-Jackson, 1867). Yet it is only during the last two decades that more focused experimental attention has been paid to this variable in the neuropsychological literature, both for brain-damaged patients and for neurologically intact individuals. In clinical neuropsychology it clearly becomes necessary to find normative criteria that may help to avoid misleading biases when assessing illiterate patients. In experimental neuropsychology research on illiteracy can provide clues for understanding the role which the ability to read and write might play in brain or cognitive organization.

Studies in non-brain-damaged illiterates have attempted to trace the influence of literacy level on the performance of tasks used for neuropsychological assessment (cf. Ardila et al., 1989; Lecours et al., 1987; Reis et al., 1994; Roselli et al., 1990). Illiterate subjects, as opposed to literate ones, may perform poorly on such tasks for three reasons: (1) the design of materials used in assessment may unduly presuppose that respondents have received schooling; (2) cognitive problem-solving strategies of literate persons may be different from those of illiterate ones; (3) literacy may directly affect functional brain organization. In fact, studies concerning the influence of literacy have actually revealed that illiterates have difficulties in solving a whole range of problems. More specifically, a link has been found between illiteracy and poor performance in linguistic tasks, such as naming, nonword repetition, and brand-name reading (Matute de Durán, 1986). It has also been reported that illiterates have deficient metalinguistic abilities, such as phonological awareness (Morais et al., 1979) and sentence production on the basis of a word list (Matute de Durán, 1986).

The connection between literacy level and visual and construction tasks is far from clear, but there is increasing evidence that illiterates have more problems than literates when it comes to managing visual information. De Clerk (1976) has found that illiterates are less capable of identifying pictures, drawings, schematic images, and figures in perspective than are literates. Reis et al. (1994) report that illiterates who perform well in naming tasks of real objects

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have difficulties in naming iconographic material. Ardila et al. (1989) have shown that illiterates have trouble negotiating spatial and praxic tasks. All these studies concern neurologically intact participants.

The present study is part of a larger project involving brain-damaged patients with differing literacy levels who were observed while performing a battery of tasks. The focus here is on stick construction by non-brain-damaged subjects in order to determine whether literacy levels can be shown to have an influence on the quality of performance in these tasks.

METHODS

Research Participants

Seventy-three neurologically healthy participants were tested. To constitute the sample, individuals were asked appropriate questions to find out whether they had antecedents of neurological or psychiatric illness; if they did not and if they were working according to their social condition, they were taken into the sample. Three groups were formed on the basis of years of schooling. According to the UNESCO studies (1979), 4 years of schooling are the minimum for functional literacy. A detailed questionnaire was designed to determine the presence of literacy, the number of years of schooling, and the daily use of reading and writing. The first group consisted of 29 illiterates: 10 men (34.5%) and 19 women (65.5%) who had never attended school and did not know how to read or write at all. The second group consisted of 21 semiliterates: 7 men (33%) and 14 women (67%) who had attended school for less than 4 years, and had learned to read and write at least their own names. The third group consisted of 23 literates: 10 men (43.5%) and 13 women (56.5%) who had attended school for more than 4 but less than 12 years, and evinced a daily use of reading and writing. Participants ranged in age from 16 to 79 years (illiterates: $M = 51.1$, $SD = 17$, range = 16–79; semiliterates: $M = 57.2$, $SD = 15$, range = 19–78; literates: $M = 39.0$, $SD = 18$, range = 16–77). The difference in age means was found to be significant according to a Kruskal–Wallis test ($p < .01$). This age-related distribution of literacy reflects educational changes taking place in the region within the life span of the participants. All were Spanish-speaking monolinguals belonging to the working or lower middle socioeconomic levels who were employed in nonqualified or menial jobs and domestic work (housewives). They were recruited from the rural and semirural area of western Mexico with the help of the National Institute for Adult Education (INEA).

Materials

The test material was composed of four stick constructions: Construction 1 was a crooked line composed of three sticks, Construction 2 was a crooked line composed of four sticks, Construction 3 was a fully symmetrical star-shaped figure with eight sticks, and Construction 4 was a schematic house of the type usually found in children's drawings, constructed in perspective with 11 sticks. The shapes were thus selected according to the increasing number of sticks used and the presence or absence of symmetry and perspective (see target constructions in Figure 1, far left column). The participants were shown the four stick constructions, one at a time, and asked to copy them by arranging small wooden sticks together on a piece of paper. The number of sticks available was always greater than the number strictly needed for the task. There was no time limit. The model was available to them for inspection at all times. From the materials standardly used to evaluate constructive apraxias stick constructions were selected in preference to either blocks or paper-and-pencil tasks to prevent differences in schooling to have an effect on performance.

Scoring

The stick constructions produced by participants were scored according to several analytic criteria (to what extent or in which respect the stick construction misrepresented the model).

The analytic criteria were grouped according to whether the construction appeared partially distorted, disarticulated, or rotated. There were four criteria for distortion: (1) acute or right angles were opened, (2) acute or right angles were closed, (3) obtuse angles were opened, (4) obtuse angles were closed. There were two criteria for rotation: (1) rotation on the same plane, either clockwise or counterclockwise, and (2) rotation on an axis. There were three criteria for disarticulation: (1) the sticks overlapped each other, (2) the sticks were too far apart from each other, and (3) the vertices were displaced. Distortion and disarticulation apply to all four figures, but rotation does not apply to Construction 3 (the symmetric star).

A maximum of three points for disarticulation were allowed for each stick construction and two points for rotation, but each figure required a different scoring for distortion given the different number of relevant angles: Construction 1 allowed for two types of distortion (one acute angle either opened or closed, one obtuse angle either opened or closed); Construction 2, three types (one acute angle opened and the other closed or *vice versa*, one obtuse angle either opened or closed); Construction 3, two types (two independent angles either opened or closed); and Construction 4, all four types. Thus all figures together yielded a maximum score of 11 distortion errors as opposed to 12 for disarticulation and six for rotation. Figure 1 shows examples of the three kinds of malformation defined by these criteria.

Additionally, the stick constructions were scored according to a global criterion of lack of fidelity (if the stick construction failed to represent the model). Since global fidelity cannot be defined because of its holistic character, it was evaluated by two independent observers on a purely nomi-

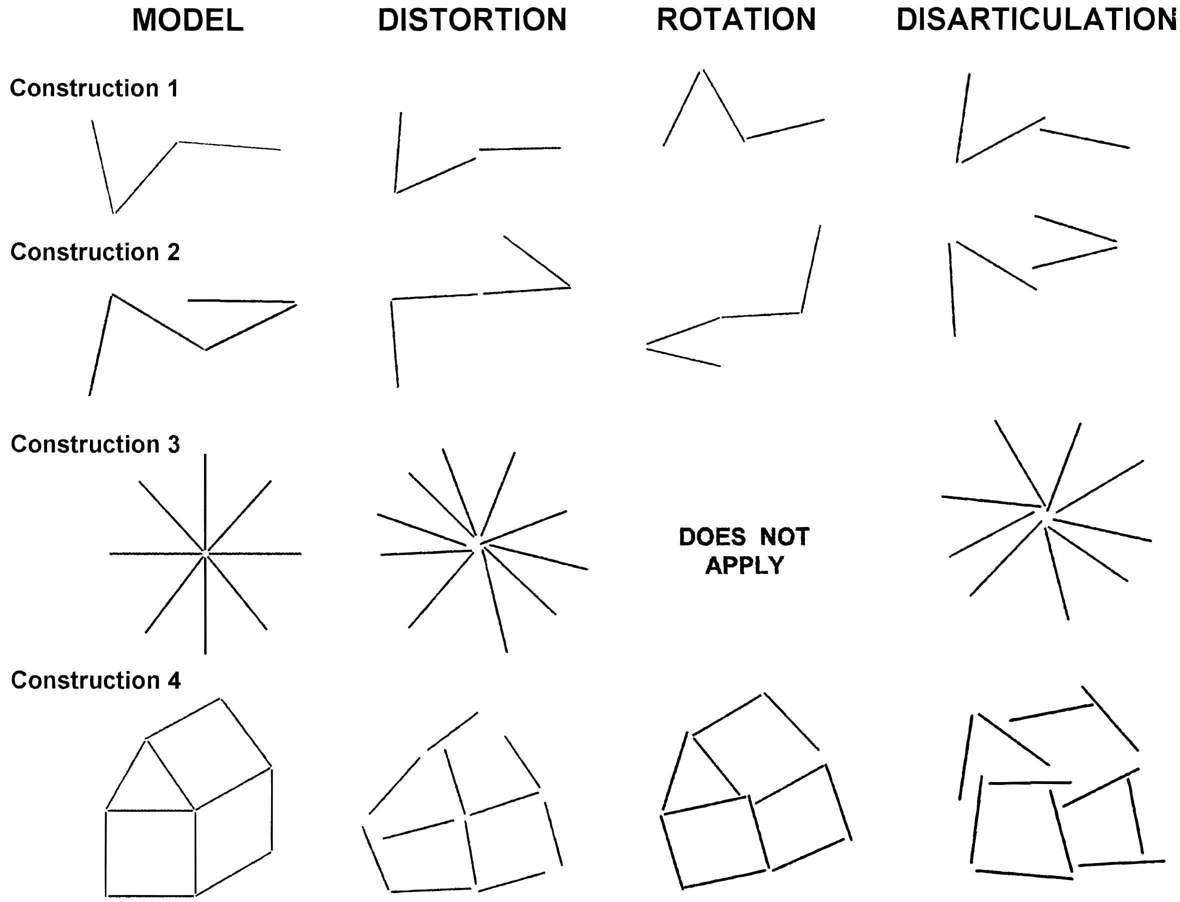

Fig. 1. The four target figures and examples of the three types of malformations.

nal basis: zero if the construction was faithful, 1 if it was not. The rating was carried out in ignorance of which group constructions belonged to. The sum of the agreements (250) was divided by the total number of constructions (292) and multiplied by 100, thus yielding a percentage of 85.6 of agreements. As opposed to the lack of global fidelity, analytic criteria are measurable and do not need to be tested for reliability. On the other hand, raters later discussed the question of how analytic criteria may have affected their holistic judgments. They agreed that rotation was not considered relevant, whereas distortion and disarticulation both played a role. In fact, it seemed that one rater gave more weight to distortion than the other, which explains the interscorer difference. Nevertheless, we still think that the holistic criterion tells a partially different story and cannot be reduced to the analytic ones.

RESULTS

Before analyzing the effect of literacy on performance and given that the number of women is almost twice that of men, performance by gender with respect to each criterion was compared by means of a Mann–Whitney test. No significant difference between men and women was found.

Analytic Criteria

Comparisons involving the three groups were carried out using a Kruskal–Wallis nonparametric analysis of variance and a significance level of .05 (chi-square corrected for ties). Table 1 contains the means and standard deviations of the error scores for each construction. When the analytic criteria were applied to each single construction, significant intergroup differences were obtained for the following: Distortion was significantly different in Constructions 1 and 4, and disarticulation was significantly different in Constructions 1, 3, and 4. However, when we applied the analytic criteria to all four constructions taken together, only disarticulation errors prove to be significantly different among groups.

Lack of Global Fidelity

Given that there were four stick construction models, the highest value for this variable which any single participant could obtain was 4 (i.e., four errors). The illiterate group obtained values ranging from zero to 4, whereas both the semiliterate and the literate groups obtained values ranging from zero to 2. The mean values and standard deviations

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Table 1. Mean errors and standard deviations for all criteria in the three groups

	Illiterates		Semiliterates		Literates	
Error type	*M*	*SD*	*M*	*SD*	*M*	*SD*
Disarticulation[b]	2.52	2.01	1.24	1.00	0.96	1.11
Construction 1[a]	0.24	0.51	0.00	0.00	0.04	0.21
Construction 2	0.28	0.59	0.10	0.30	0.04	0.21
Construction 3[b]	0.69	0.85	0.10	0.30	0.26	0.54
Construction 4[a]	1.31	0.93	1.05	0.80	0.26	0.66
Rotation	0.95	1.13	0.52	0.93	0.52	0.67
Construction 1	0.61	0.74	0.24	0.54	0.35	0.57
Construction 2	0.24	0.51	0.14	0.36	0.17	0.39
Construction 4	0.17	0.39	0.14	0.36	0.00	0.00
Distortion	3.43	2.00	4.10	2.55	2.74	1.91
Construction 1[a]	0.83	0.80	0.57	0.68	0.30	0.56
Construction 2	1.31	1.00	1.33	0.73	1.30	0.56
Construction 3	1.24	0.99	0.81	0.98	0.70	0.97
Construction 4[a]	0.43	0.99	1.38	1.63	0.43	1.20
Global Fidelity[c]	1.03	1.18	0.29	0.56	0.09	0.42

[a]$p < .05$; [b]$p < .01$; [c]$p < .001$.

are shown in Table 1. The Kruskal-Wallis test yielded a highly significant value (corrected $\chi^2 = 16.58$, $p < .001$).

If we assess errors of fidelity in each single construction, then the performance on the most complex stick construction task, Construction 4, is of the highest interest: only 15/29 participants (52%) of the illiterate group performed correctly according to this criterion in contrast to 16/21 (76%) semiliterates and 22/23 (96%) literates (see Figure 2).

No variable, or combination of variables, evinced significant differences when the performance outcomes of male and female participants were compared.

DISCUSSION

Diagnostic assessment of constructional apraxia uses different procedures. Copying is generally preferred because researchers assume that it is less influenced by cultural level (Carlesimo et al., 1993). However, the present study suggests that literacy level plays a subtle causal role on performance in copying stick constructions. The results reviewed indicate that neither distortion nor rotation errors allow discrimination between the three groups. On the other hand, both disarticulation errors and errors of global fidelity es-

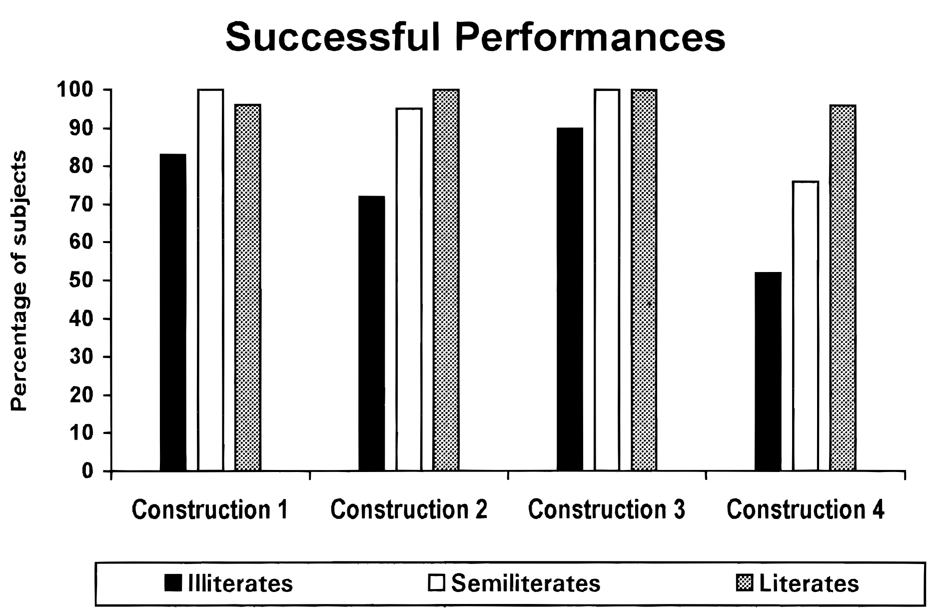

Fig. 2. Percentages of participants with successful performances.

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tablish a significant difference between literates and illiterates (see Table 1).

The ability to form and distinguish letters is related to our three analytic criteria. All three kinds of errors could confound the shapes of letters in slightly different ways. Thus the distinction between ***u*** and ***n*** would be impaired by distortions (widening and narrowing of angles), that between **p**, **q**, **d**, and **b** would be affected by rotations, and that between **M** and **NI** or between **N** and **IV** would be affected by disarticulations. It is clear, therefore, that distortion and rotation only affect writing performance at the level of individual letters, whereas disarticulation is related to the ability of linking letters to each other, which is required in order to write whole words. We suggest that the results of this study can be explained by the possibility that the articulation of whole words is a deeper feature of literacy than either control over angles or spatial orientation. Notice also that disarticulation (i.e., separation of lines) is not in itself an error. It counts as an error only when the participant disarticulates what should have been articulated, as was the case in the constructional tasks used in our study. However, under a different experimental design one could induce errors consisting of articulating what should have been disarticulated. The ability of articulating and disarticulating (according to a given task) is one and the same, and writing requires both aspects. In fact, appropriate disarticulation is a crucial requirement for the writing of a whole text, implying separation of words. Therefore, although this study does not provide proof, the disarticulation errors evinced by illiterates may be a sign of a deeper disability involving both articulation and disarticulation.

The number of errors of global fidelity in Constructions 1, 2, and 3 is very similar in both semiliterates and literates as opposed to illiterates, a similarity that disappears in the case of the more complex Construction 4. This indicates that acquisition of a modest level of literacy allows for a limited increase in the quality of performance on constructional tasks, but only full literacy produces substantial improvement (see Figure 2).

Finally, the question remains as to how the three analytic criteria are related to the global one. It should be clear that rotation (which, mathematically speaking, is a symmetry-preserving operation) cannot alter the fidelity of a representation. Distortion does affect fidelity but in a less drastic way than disarticulation; that is, it changes some of the geometrical relations but does not destroy them as much as disarticulation does. This explains why only disarticulation errors and errors of fidelity discriminate between the three groups (see Table 1).

Although socioeconomic variables were controlled in this study, we are aware that other variables originating in schooling, yet different from literacy, might be affecting performance outcomes, such as familiarity with testing situation, visual tracking habits, use of certain disciplined problem-solving strategies, etc. Nevertheless, those variables cannot be disentangled from literacy in itself, for there is no way to have participants who are at once illiterate, schooled, and non-brain-damaged. Therefore, given that constructional apraxia is very widespread among brain-damaged individuals, with an incidence of up to 40% (Carlesimo et al., 1993), more attention should be paid to the causal influence of literacy level or other cultural factors.

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