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ABSTRACT
This study reports the observations gathered from 11 children referred to consulting services because of learning difficulties at school and diagnosed with nonverbal learning disabilities (NVLD). These children had an average verbal IQ, but a WISC-R performance IQ lower than the verbal IQ by at least 15 points and experienced difficulties especially in mathematics and drawing. The children completed a battery of four tasks requiring visuospatial working memory and visual imagery: a memory task composed of pictures and their positions (Pictures task), a task that required them to memorize the positions filled in a matrix (Passive Matrix task), a task that required them to imagine a pathway along a matrix (Active Matrix task) and a task that required them to learn groups made up of three words, using a visual interactive imagery strategy (TV task). In comparison to a control group of 49 children, children with NVLD scored lower in all the tasks, showing deficits in the use of visuospatial working memory and visual imagery. By contrasting subgroups of children of different ages in the control group, it was possible to show that some tasks did not show a clear developmental trend. Thus the deficits shown by the children with NVLD cannot simply be attributed to a developmental delay of these children, but seem to reflect a more severe disability.

Nonverbal learning disabilities (NVLD) are found in children with learning disabilities who have relatively good linguistic abilities but poor nonverbal abilities (Denckla, 1993; Fisk, Fuerst, & Rourke, 1990). A nonverbal learning disability has been described in the literature as an imbalance between verbal and nonverbal skills, but with some differences and peculiarities. In particular, some authors (Nichelli & Venneri, 1995; Tranel, Hall, Olson, & Tranel, 1987; Voeller, 1986; Weintraub & Mesulam, 1983) have described children with similar disabilities, ascribing them to deficits in the functioning of the right hemisphere. Weintraub and Mesulam (1983) described a group of young adults with social-emotional problems who were found to have cognitive deficits implicating the right hemisphere. Nichelli and Venneri (1995) described a 22-year-old man with a developmental learning disability consisting of arithmetic difficulties, visuospatial deficits, and emotional difficulties but with good verbal abilities, consistent with the diagnosis of a "right hemisphere developmental learning disability." A positron emission tomography (PET) scan revealed a marked hypometabolism of the man's right hemisphere, supporting the hypothesis that the disability was indeed associated with functional abnormalities of the right hemisphere. Denckla (1993) has suggested that deficits found in right hemisphere learning disabilities may be distinguished depending on the damaged right hemisphere area.

The most systematic effort in the study of nonverbal learning disabilities has been made by Rourke and colleagues (see Rourke, 1989, for a review). Children with nonverbal learning disabilities typically experience a variety of academic difficulties (mainly in reading comprehension, mechanical arithmetic, mathematics, and science) and a discrepancy of at least 10 points between the verbal IQ and the performance IQ, typically measured with the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974). In a wide range of studies, Rourke and colleagues described numerous deficits that can be found in children with nonverbal learning disabilities, affecting cognitive abilities such as tactile and visual perception, complex psychomotor abilities, elaboration of new material, tactile and visual attention, exploratory behavior, tactile and visual memory, concept formation, problem solving, and nonverbal aspects of language such as prosody (Rourke, 1989; Fisk et al., 1990; Harnadek & Rourke, 1994).

Cornoldi, Dalla Vecchia, and Tressoldi (1995) found that young adolescents with high verbal intelligence and low visuospatial intelligence presented marked deficits in a series of visuospatial working memory tasks. They argued that, as the visuospatial working memory is presumably involved in a variety of more complex activities, these deficits could underlie many difficulties experienced by children with low visuospatial intelligence and nonverbal learning disabilities. To explain these deficits, they proposed a model of visuospatial working memory that distinguished between passive and active visuospatial components (see also Vecchi, Monticelli, & Cornoldi, 1995). These components could be characterized as disposed along an activity continuum, ranging from a completely passive pole involved in the storage of visuospatial information to active operations involved in the generation, manipulation, and transformation of visuospatial representations (Cornoldi, 1995). One important aspect of this model is that active visuospatial working memory operations involve the generation and manipulation of mental images created on the basis of verbal descriptions. In fact, visuospatial working memory deficits in children with low visuospatial intelligence seem to involve not only the passive, but also the active components of the system (Cornoldi et al., 1995).

Deficits in visuospatial working memory and in visual mental imagery have not been specifically studied in children with NVLD. Only some incidental references are found in the literature. For example, Denckla (1993) observed that adults with a nonverbal learning disability "manifest not only visuospatial difficulties, but also deficient visualization, visual imagery, and configurational processing even when no external perception is involved" (p. 119). An impressive wealth of evidence (e.g., McDaniel & Pressley, 1987) has demonstrated the critical role of visual imagery strategies in improving the learning capacities of children with learning disabilities.

All this evidence supports the importance of evaluating the mental imagery abilities of children with NVLD. In this study, we investigated this point by comparing the performance of a group of children with NVLD to a control group in a series of four tasks. The tasks involved visuospatial working memory and visual mental imagery, but to some extent also verbal abilities. Two of the tasks required the children to recall positions in grids and drawings of objects related to these positions. The other two tasks required the children to imagine either a pathway or interactive images in an associative task following verbal instructions.

Despite its apparent automaticity, a memory for position requires visuospatial working memory abilities, which develop with age (Schumann-Hengsteler, 1992) and may be poor in children with low visuospatial intelligence (Cornoldi et al., 1995). The role of memory for
the names of objects remains more controversial, as verbalization may offer a valid alternative strategy to children with good verbal abilities. However, in a task involving memory for figures, children seem to use a visual code more successfully than a verbal code (Hitch, Woodin, & Baker, 1989), whereas adults take advantage both of the verbal and of the visual code (Paivio, 1971). For this reason, we expected that children with NVLD would not do as well as controls both in recalling positions and in recalling objects, but that they would show greater difficulty with the recall of positions.

Despite the use of verbal instructions, the task of following a mental pathway requires the use of visual mental imagery in order to be successfully carried out; children with a visual imagery deficit are expected not to perform as well in this task as control children (Cornoldi, Cortesi, & Preti, 1991).

Apparently, children with NVLD have a good verbal associative memory (Harnadek & Rourke, 1994). Both Weintraub and Mesulam (1983) and Nichelli and Venneri (1995) described instances where children with NVLD performed well in standard paired-associate learning tasks. However, these tasks did not rely substantially on the use of visual imagery. Many studies (e.g., Paivio, 1971) have shown that visual mental imagery may enhance the memory for paired associates. Furthermore, it has been shown that congenitally blind people, who are hypothesized to have visual mental imagery limitations, may have difficulty in using mental imagery when they have to memorize three or four words together rather than simple pairs (De Beni & Cornoldi, 1988). It has been shown that 5- to 8-year-old children, including children with mental retardation matched for mental age, may also take advantage of the use of an imagery strategy (Cornoldi & Vianello, 1992). However, if children with NVLD have difficulty in the use of visual mental imagery, they should also have difficulty with this task despite their good verbal abilities.

The four tasks were presented to a group of 11 children with NVLD referred to clinical services and to a control group of children matched for verbal intelligence and socioeconomic status. The control group was selected to obtain an adequate number of children of three different ages. This made it possible to evaluate whether the four tasks identified developmental trend. In this way, hypothesizing that children with NVLD would perform less well at all four tasks, we were able to evaluate whether their deficits represented an earlier developmental stage of that ability or if they had a specific deficit not clearly associated to the performance of the youngest children’s control subgroup.

**METHOD**

**PARTICIPANTS**

Eleven children (8 boys and 3 girls) with learning disabilities were referred to clinical services in the Veneto area of northeastern Italy on account of their difficulties at school. Clinical evaluation suggested a diagnosis of nonverbal learning disability (NVLD). In particular, all the subjects presented a strong discrepancy (at least 15 points) between verbal IQ (M = 100.9, SD = 13.57) and performance IQ (M = 77.45; SD = 12.89) measured on the WISC-R scale. Furthermore, the children experienced considerable difficulties (with an achievement level at least 18 months below their grade) in some school subjects, particularly, mathematics (arithmetic, geometry) and handwriting, and in some emotional-relational aspects. The children’s age ranged from 7 years 5 months to 13 years (M = 9 years 10 months). Their individual characteristics are presented in Table 1.

The control group consisted of 49 children from the same area, whose ages ranged from 7 to 11 years (M = 9 years 5 months). These children included 16 third-graders, 15 fourth-graders, and 18 fifth-graders. Although we were not permitted to administer a standardized intelligence test, these children were rated by their teachers as comparable in their verbal abilities to the children with NVLD (mean estimated verbal IQ = 100) and within the normal range of scholastic achievement. The teachers’ evaluation was comprehensive and based on the children’s school achievement records in different subjects.

**MATERIALS**

The four tasks used in this study are presented in detail in the Appendix. In the Pictures task, already used by Cornoldi et al. (1995), the children were required to recall the names and the positions of familiar objects whose drawings were illustrated in a 4 × 4 matrix. Three matrices included four drawings, three included six, and three included eight drawings. Children had to look at a matrix for 30 seconds. Immediately after the matrix was removed, the children were asked to recall the filled positions and the objects in those positions.

Memory for position was explored in a second task: the Passive Matrix task, where a 5 × 5 matrix was presented with either three, four, or five positions filled. After the matrix was removed, the child had to indicate on a blank matrix which positions had been filled. The matrix was presented six times, twice for each number of filled positions. This task preceded a second, related task: the Active Matrix task, which required the child to imagine moving through a 3 × 3 matrix. The child was shown a starting point on a matrix (the bottom left square), then the matrix was removed, and for the entire task she or he had to rely on mental imagery to follow the verbal instructions given by the experimenter.

For the fourth task, the TV task, we borrowed the metaphor of the television screen from Ross and Ross (1978). Ten groups of three words each describing familiar objects were read to the child, who was invited to imagine the objects as if they were being presented in an interactive way on a TV screen.

All four tasks were taken from previous experimental research that had demonstrated their discriminant validity in the analysis of group differences (Cornoldi et al., 1995; Cornoldi & Vianello, 1992). In this study, we took the opportunity to obtain more information about their psychometric properties.

**PROCEDURE**

All the children were individually tested, with the four tasks administered in the following order: TV task, Passive Matrix task, Active Matrix task, Pictures task. The measurement tasks were preceded by practice trials in order to verify that the children had understood the instructions.

**RESULTS**

We analyzed the reliability of all the instruments using the data obtained from the control groups. The Cronbach alpha was .77 for the TV task, .61 for the two parts of the Matrix task, and .81 for the Pictures task, suggesting that the tasks had a sufficient level of internal consistency.

Figure 1 presents the mean percentage of errors made by the two groups in the Pictures task. Errors were classified according to the complexity of the patterns (patterns with 4, 6, and 8 figures) and according to the type of error (spatial = not remembered or incorrect positions; visual = not remembered or incorrect names of the objects). A 2 × 2 × 3 ANOVA (Group × Type of error × Complexity) with a
mixed design revealed significant main effects for group, $F(1, 58) = 14.96, \text{MSE} = .10, p < .001$, and for complexity, $F(2, 116) = 72.81, \text{MSE} = .01, p < .001$. Moreover, the interaction between group and type of error was significant, $F(1,58) = 15.63, \text{MSE} = .02, p < .001$. The interaction between complexity and type of error was also significant, $F(2,116) = 7.18, \text{MSE} = .01, p < .001$. Figure 1 shows that the children with nonverbal learning disabilities showed a poorer performance in general but made a particularly high number of spatial errors, not only with respect to the control group but also with respect to their own visual errors—the opposite of the control group. In fact, the mean percentage of their spatial errors was 24.63% ($SD = 14.8$) compared to 19.27% ($SD = 9.4$) of visual errors, $t(10) = 2.08, p = .064$, whereas the control group’s corresponding spatial and visual error percentages were 11.9% ($SD = 7$) and 14.5% ($SD = 6.48$), respectively, $t(48) = 3.09, p < .003$.

The comparison between the different grades in the control group revealed a clear and significant trend of decrease in visual errors, from 17.05% ($SD = 7.3$) in third-graders through 14.85% ($SD = 7.08$) in fourth-graders to 11.55% ($SD = 3.7$) in fifth-graders. This trend was less evident for spatial errors: 13.99% ($SD = 8.9$), 13.72% ($SD = 6$), and 8.65% ($SD = 4.9$), respectively (see Figure 2).

Figure 3 presents the mean percentage of correct responses by the two groups for the two Matrix tasks. In the Passive Matrix task, a response was deemed correct when the correct position was filled by the child. In the active task, a response was correct when the child was able to point on a blank 3 × 3 matrix to the correct final position of the mental pathway. The mean scores were 29 ($SD = 30$) and 40 ($SD = 22$), respectively, for the NVLD and the control group.

Separate t-tests for the Passive and Active Matrix tasks revealed a significant difference between the two groups only in the active task, $t(58) = 2.72, p = .009$. As for the spatial score in the Pictures task, neither the Passive nor the Active Matrix tasks revealed a clear developmental trend, because differences between grades did not show significant differences. In the Passive Matrix task, the mean number of correct responses was rather similar for the three grades: 16.9 ($SD = 3.1$), 16.60 ($SD = 2.58$), and 17.01 ($SD = 4.04$) respectively, out of 24 possible correct responses. In the Active Matrix task, the difference between grades was likewise modest: the mean number of correct responses was respectively 2 ($SD = 1.2$), 2.2 ($SD = 1.2$), and 2.94 ($SD = 1.3$), out of 3 possible correct responses.

The mean performance on the TV task was significantly different between the groups. We analyzed the number of the words correctly remembered and associated with the cue word by each child in the control group and by 9 of the 11 children in the experimental group. (Unfortunately, two children with NVLD had problems in completing the task.) The mean number of correct responses (out of a maximum of 20) was 5.66 ($SD = 5.20$) for the group with nonverbal learning disabilities and 12.03 ($SD = 5.25$) for the control group; the difference was significant, $t(56) = 3.86, p < .001$.

In this case, the comparison between children of different grades revealed a significant age effect (see Figure 4). The mean number of words recalled by third-graders was 9.87 ($SD = 4.5$). Performance increased notably for the fourth-graders, $M = 13.20, SD = 3.7$, and then remained at approximately the same level for the fifth-graders, $M = 13.00, SD = 6.08$.

**DISCUSSION**

Most children with learning disabilities present more severe deficits in verbal skills than in nonverbal skills. However, some children present a different profile, with the imbalance between verbal and nonverbal skills inclined towards a lower level of the latter. Moreover, it has been suggested that these children can develop not only severe learning difficulties, but also important personality problems (e.g., Rourke, 1989).

Researchers have studied cognitive, neuropsychological, personality, and school learning aspects of NVLD. However, to our knowledge no previous research has studied the ability of children with NVLD to cope with two important categories of tasks related to visuospatial working memory and visual mental imagery. These tasks are important because they underlie many everyday activities and learning situations (see Logie, 1995; McDaniel & Pressley, 1987). Furthermore, visuospatial working memory seems to be strictly interconnected with the generation and maintenance of mental images (Baddeley, 1986; Cornoldi, 1995; Cornoldi et al., 1995). This study offers evidence that children with NVLD may present conspicuous deficits in tasks that require the use of visuospatial working memory and of visual mental imagery. Furthermore, some of these deficits do not seem to reflect development lags, which are easily observed in normal children, suggesting that children with NVLD are not simply affected by a developmental delay.

The results obtained in this study concern a small group of children with learning disabilities who received a diagnosis of NVLD on the basis of a discrepancy between their verbal and nonverbal abilities and poor achievement in areas less directly dependent on language. Because the diagnostic criteria for NVLD can differ from country to country, we must be cautious in generalizing our findings to other samples of learning disabled children who have been diagnosed with a nonverbal syndrome. However, our results have seemed useful in extending comprehension of the cognitive characteristics underlying this syndrome.

The low performance of children with NVLD in the Pictures task demonstrates that these children have difficulty in performing visual working memory tasks for both the types of information that we tested, namely spatial information and visual information. Furthermore, the interaction between groups and type of information suggests that the two types of information can be distinguished. This distinction could be related to the classical distinction between spatial and visual components of the visual working memory (e.g., Baddeley, 1986). The possibility that visual stimuli are linguistically encoded is not particularly likely in young children (Hitch et al., 1989). However, it is possible that children with NVLD try in a particularly hard way to overcome their visual difficulties by using their high linguistic competence, which involves a dual encoding, both verbal and visual, of the pictures (Paivio, 1971). This hypothesis could explain why children with NVLD have less difficulty with visual information than with spatial information.

The data obtained from the Pictures task are directly comparable with the data previously obtained by Cornoldi et al. (1995) using the same task administered to children with low visuospatial intelligence. In general, these data show a similar difficulty with the tasks in the experimental groups of both studies. However, the children with low visuospatial ability in Cornoldi et al.’s study presented less severe difficulties and did not show the differences between spatial and visual patterns of errors that we found in children with NVLD. These data suggest that the two groups, beside large similarities, also present some differences. Even within the experimental group with NVLD, we could observe rather different profiles. For example, we found children whose performance was not particularly poor, that is, above a cutoff score of 1 negative SD in one or more tasks. Respectively 5, 3, 5, 5, and 3 children with NVLD were at or above the cutoff score in the visual and spatial errors on the Pictures task, and on the correct responses in the Active Matrix, Passive Matrix, and TV tasks.

Data obtained from tasks other than the Pictures task cannot be directly compared to preceding research, as they represent a new attempt to study children with visuospatial problems. In particular, the two Matrix tasks offer the possibility of examining mental imagery deficits in NVLD, that are present even when the mental images are generated by verbal instructions. The two Matrix tasks allowed us to compare a task that simply required short-term memory of spatial information (Passive Matrix task) with a task that required an operation on that information using verbal input (Active Matrix task). The finding that children with NVLD show difficulty with verbal input confirms the hypothesis that their problem is not only related to the treatment of visual input but also involves more general operations of visual working memory, including mental imagery tasks. In Cornoldi et al.’s (1995) study, two similar tasks had to be performed simultaneously; it seemed...
that young adolescents with low visuospatial ability were having more problems with the Active than with the Passive Matrix task. This result was interpreted by Cornoldi and coauthors in terms of the hypothesis of fractionability of the passive and active components of visuospatial working memory (Vecchi et al., 1995). In this study, the tasks were modified so that children were not required to do them simultaneously. However, the results replicated the previous findings of Cornoldi et al. (1995) by showing that in a simple passive memory task for location, children with poor visuospatial abilities have less problems than in the corresponding active task. The modifications to the Matrix tasks also made them appropriate for the youngest group of children, who did as well as the oldest children. This last result shows that the poor performance of children with NVLD is not an example of performance matched by children who are a few years younger, but that it represents a severe specific problem. Children who are unable to mentally follow a simple pathway in a 3 × 3 matrix will probably meet difficulties in understanding and representing simple descriptions and situations that require spatial processes. In fact, Rigoni, Cornoldi, and Alcetti (1997) have found that children with NVLD have problems either in drawing or in locating objects in correspondence with verbal descriptions of spatial arrangements.

The difficulty experienced by children with NVLD in the generation and use of mental images from verbal instructions was confirmed by their poor performance on the TV task. Previous research (Nichelli & Venneri, 1995) has shown that children with NVLD do not have problems with standard paired-associate tasks, represented by the associative memory subtest of the Wechsler memory scale (Wechsler, 1945), that do not require the use of mental images. Other research (e.g., Cornoldi & Vianello, 1992) has shown that even young children can profit by using mental images in associative learning. The data obtained on the controls in this study show that this benefit increases with age. Furthermore, this study shows that in spite of their good verbal abilities children with NVLD have problems with associative learning tasks that require the use of mental images.

Taken together, the data gleaned from this study show that children with NVLD have problems with visual working memory and visual imagery tasks. As children with NVLD performed poorly in all four tasks we proposed, it might be hypothesized that they would be in general less competent in cognitive tasks. However, this cannot explain why these children did not do poorer than controls in the verbal tasks of the WISC-R battery. From a theoretical point of view, the results obtained offer information concerning the characteristics of the tasks that we proposed and the processes involved. In particular, the poor performance of children with NVLD in the imagery tasks that used verbal material and verbal instructions confirms the hypothesis that these tasks require not only verbal processes, but also processes related to nonverbal abilities. The specific contribution of a nonverbal component in the generation of interactive images required for associating verbal items has sometimes been doubted. For example, it has been suggested that the effects of interactivity could be due to relational organizational processes (see McGee, 1980). However, the children with NVLD in our study did not do badly in the WISC-R Similarities subtest, which requires the identification of relationships between items. In contrast, they performed poorly in the TV task, suggesting that the interactive imagery requirement actually involved specific nonverbal processes.

It must be noted that the two imagery tasks we proposed were rather different. The Active Matrix task mainly involved spatial processes, whereas the TV task mainly involved visual processes. In fact, in the TV task it was critical that the child generated clear images of each object and selected possible details that could interconnect objects. Taking an example from the Appendix, one can imagine a house and within the house a pair of scissors cutting a sweater. In this image the spatial disposition of the objects is not as critical as the possibility of obtaining good images of the objects and of the details more directly associated with interaction (e.g., the top of the scissors cutting the sweater). Therefore, combining the data from the TV task and the Pictures task, it is possible to hypothesize that children with NVLD have difficulties with both the visual and the spatial components of visual working memory. However, their deficit with spatial components seems to be more severe. They had more difficulty remembering spatial information in the Pictures task and showed a weaker imagery performance even for tasks in which no developmental differences could be found (Active Matrix task). This observation requires further study not only of the children’s abilities, but also of the dissociation between the visual aspect and the spatial aspect and of the procedures used for testing this dissociation.

We must be cautious in considering the distinction between the passive and active components of visual working memory, which were tested here with the Pictures task and the Passive Matrix task on the one hand and with the TV task and the Active Matrix task on the other hand. Contrary to previous research (Cornoldi et al., 1995; Vecchi et al., 1995), we were unable to find clear differences between the active and passive components, as the children with NVLD performed poorly in both aspects. It has sometimes been suggested (e.g., Hasher & Zacks, 1979) that the passive storage of visuospatial information is automatic and does not reflect clear individual differences. This hypothesis does not seem to apply to our data. In our tasks, in which the request for encoding information in visuospatial terms was explicit and presumably involved controlled processes, we found clear differences between the groups.

A more general theoretical problem concerns the possibility that specific visuospatial working memory and visuospatial imagery problems simply reflect a more general deficit in the processing of visuospatial information. However, this hypothesis makes it difficult to explain specific differences that were found between the different tasks. In particular, Cornoldi et al. (1995) found that children with low visuospatial intelligence had more problems in solving puzzles when they had to rely on a visuospatial working memory trace.

From a practical point of view, our results offer some suggestions concerning the treatment of NVLD. Reference to visual working memory and mental imagery can offer a more detailed focus for clinical and educational work. Specific operative suggestions can also be made. With respect to visual working memory limitations, one implication concerns the use of situations that do not require too much information to be kept in memory. For example, requests for a drawing aimed at the comprehension of spatial descriptions for the solution of geometrical problems should propose a limited number of elements. Furthermore, children with NVLD could be helped to recognize their memory problems and taught how to overcome them by using particular strategies (writing, verbalization, division of material in manageable parts, etc). With respect to imagery limitations, instructions that make tasks easier for other children are not only unable to help children with NVLD, but actually create confusion. Children with NVLD should either receive different suggestions or be helped to develop more experience in the use of imagery strategies. In fact, nonverbal imagery processing limitations may also be due to lack of practice or to slower processing speed. Giving children with NVLD the opportunity of processing visual imagery more slowly or of developing sufficient expertise in the imagery tasks could reduce their problems.

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AUTHORS’ NOTE

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TABLE 1 Characteristics of Children with Nonverbal Learning Disabilities

<table>
<thead>
<tr>
<th>Child</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Clinical diagnosis</th>
<th>Verbal IQ</th>
<th>Performance IQ</th>
<th>Educational problems</th>
<th>Emotional and behavioral problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.</td>
<td>M</td>
<td>10.16</td>
<td>Learning disability</td>
<td>105</td>
<td>81</td>
<td>Math; Handwriting; Geography</td>
<td>none</td>
</tr>
<tr>
<td>N.</td>
<td>M</td>
<td>8.6</td>
<td>Specific motor</td>
<td>96</td>
<td>80</td>
<td>Math; Handwriting</td>
<td>mild attention disorder</td>
</tr>
<tr>
<td>G.</td>
<td>F</td>
<td>11.2</td>
<td>Hydrocephaly</td>
<td>72</td>
<td>45</td>
<td>Math; Drawing</td>
<td>mild attention disorder</td>
</tr>
<tr>
<td>Ni.</td>
<td>M</td>
<td>9.9</td>
<td>Learning disability</td>
<td>128</td>
<td>85</td>
<td>Geometry; Handwriting</td>
<td>none</td>
</tr>
<tr>
<td>M.</td>
<td>M</td>
<td>8.8</td>
<td>Mild learning</td>
<td>108</td>
<td>93</td>
<td>Math</td>
<td>none</td>
</tr>
<tr>
<td>E.</td>
<td>M</td>
<td>7.4</td>
<td>Learning disability</td>
<td>92</td>
<td>73</td>
<td>Handwriting</td>
<td>difficulties in social relations</td>
</tr>
<tr>
<td>V.</td>
<td>F</td>
<td>9</td>
<td>Learning disability</td>
<td>105</td>
<td>83</td>
<td>Math; Text Comprehension</td>
<td>low self-esteem</td>
</tr>
<tr>
<td>L.</td>
<td>M</td>
<td>9.4</td>
<td>Learning disability</td>
<td>96</td>
<td>80</td>
<td>Math; Handwriting</td>
<td>difficulties in social relations</td>
</tr>
<tr>
<td>Pa.</td>
<td>M</td>
<td>9.4</td>
<td>Learning disability</td>
<td>98</td>
<td>82</td>
<td>Math</td>
<td>none</td>
</tr>
<tr>
<td>P.</td>
<td>F</td>
<td>10.6</td>
<td>Learning disability</td>
<td>102</td>
<td>85</td>
<td>Math; Text Comprehension</td>
<td>difficulties in social relations</td>
</tr>
<tr>
<td>F.</td>
<td>M</td>
<td>13</td>
<td>Learning disability</td>
<td>108</td>
<td>65</td>
<td>Math</td>
<td>none</td>
</tr>
</tbody>
</table>

FIGURE 1. Mean percentage of errors in the Pictures task by the group of children with nonverbal learning disabilities (NVLD) and by the control group. Errors are given separately for the matrices with 4, 5, and 8 objects and depending on whether the child failed to remember the name of the object (visual) or the position occupied by the object (spatial).

FIGURE 2. Total mean number of visual and spatial errors made by the control children by grade.

FIGURE 3. Mean percentage of correct responses given by the group of children with nonverbal learning disabilities (NVLD) and by the control group in the Passive and Active Matrix tasks.

FIGURE 4. Mean number of correct responses in the TV task made by the control subjects by grade.

REFERENCES


APPENDIX PRESENTATION OF THE TASKS

TV TASK
This task requires the participants to remember groups of three words using an interactive visual imagery strategy. Groups of three words are read to the children at the rate of 1 second per word. Words are all high-imagery, high-frequency words. The researcher suggests that they convert each word into the corresponding image and form a three figure chunk to conserve the image in memory. Children are told to do the TV game: "Imagine a big screen in front of you where you will see each figure that is mentioned appear ...." At the end of the presentation phase, the experimenter gives the first "anchor" word of each group, and the children have to recall the other two words that were associated with it. The children score well if they recall a lot of the terms contained in the list.

1. house--scissors--sweater
2. shoe--butterfly--violin
3. book--tree--picture
4. cage--cat--watch
5. doll--window--bicycle
6. bee--glasses--car
7. apple--brush--tortoise
8. saucepan--telephone--notebook
9. umbrella--children--arm-chair
10. pen--flower--fish

MATRIX TASKS
Passive memory task. The children are shown a 5 × 5 bidimensional board made up of 25 squares, some of them colored in yellow; two boards have only three colored cubes in various positions, two have four colored cubes, and two have five. The children are shown the matrix for 10 seconds. Then the matrix is removed, and the children are asked to indicate on a white matrix the positions of the previous yellow squares. The score is the number of positions that children are able to recall correctly.

Active memory task. Using a 3 × 3 matrix in which only the bottom left square is colored in red (the starting point), the children are instructed to imagine a mental itinerary listening to the experimenter's verbal indications to go right, left, up, or down. At the end of each route they have to indicate where the itinerary stops on the matrix.

Children were examined beforehand for their correct comprehensions of spatial terms and of the task. Children are presented with the descriptions of three itineraries, each including six commands presented at the rate of approximately 2.5 seconds per command.

PICTURES TASK
The test consists of nine trials. There are three trials each made up of either four, six, or eight drawings of familiar objects (e.g., a dress, a cake, a castle, a pig) located on a 4 × 4 matrix. For each trial, the experimenter asks the child if all the pictures are clear and then invites him or her to observe the matrix for 30 seconds, memorizing both the figures and their positions. If a picture is not clear to the child, it is named by the researcher. The matrix is then removed and the children are asked to recall the names of the figures and to show their positions. When children are unable to recall both pieces of information, they are asked to give either the positions or the names alone. Two scores are computed. A spatial score represents the number of correct locations remembered. The visual score represents the number of pictures remembered. (Each verbal response that refers to the pictures is considered valid.)

FIGURE A. Matrix for passive matrix task.
FIGURE B. Matrix for active matrix task.
FIGURE C. Examples of matrix for Pictures task.