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Article

Specific Language Impairment: A Neuropsychological Characterization[1]

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Abstract: This study's objective was to characterize the neuropsychological functioning of children with Specific Language Impairment (SLI), in the areas of visual and verbal memory, attention/executive functions, and visual-perceptual functions. The sample consisted of 28 children with SLI and 28 children without SLI. Both groups were comparable in terms of age, gender, school grade and socioeconomic level. The assessment instruments used are part of Coimbra's Neuropsychological Assessment Battery and data were analyzed through parametric and nonparametric statistical tests. In general, the results differentiate the performances of children with SLI from those observed in children without SLI. In comparison to the control group, the group of children with SLI obtained poorer results in visual memory and verbal memory, selective and sustained attention, executive functions, semantic verbal fluency, visual-perceptual functions and processing speed.

Keywords: neuropsychological assessment, language disorders

Distúrbio Específico de Linguagem: Caracterização Neuropsicológica

Resumo: O presente estudo pretende caracterizar o funcionamento neuropsicológico de crianças com Distúrbio Específico de Linguagem (DEL) nas áreas da memória visual e verbal, atenção/funções executivas e funções visuopercetivas. A amostra é constituída por 28 crianças com DEL e 28 crianças sem DEL, sendo ambos os grupos equiparáveis em termos de idade, género, ano de escolaridade e nível socioeconómico. Para o efeito, recorreu-se a testes da Bateria de Avaliação Neuropsicológica de Coimbra e os dados foram analisados através de testes estatísticos paramétricos e não paramétricos. De um modo geral, os resultados obtidos diferenciam os desempenhos das crianças com DEL dos observados em crianças sem DEL. Em concreto, e comparativamente ao grupo de controlo, o grupo de crianças com DEL apresentou resultados significativamente inferiores na memória visual e memória verbal, na atenção seletiva e sustentada, nas funções executivas, na fluência verbal semântica, nas funções visuopercetivas e na velocidade de processamento.

Palavras-chave: avaliação neuropsicológica, distúrbios da linguagem

Trastorno Específico del Desarrollo del Lenguaje: Caracterización Neuropsicológica

Resumen: Este estudio trata de caracterizar el funcionamiento neuropsicológico de niños con Trastorno Específico del Desarrollo del Lenguaje (TEDL) en las áreas de la memoria visual y verbal, atención/funciones ejecutivas y funciones visuoperceptivas. La muestra abarcó a 28 niños con TEDL y 28 niños sin TEDL, ambos grupos equiparables en términos de edad, género, nivel de escolaridad y nivel socioeconómico. Para tal efecto, se aplicó los test de la Batería de Valoración Neuropsicológica de Coimbra y los datos fueron analizados con testes estadísticos paramétricos y no paramétricos. En general, los resultados obtenidos diferencian los desempeños de los niños con y sin TEDL: el grupo de niños con TEDL presentaba resultados significativamente inferiores en la memoria visual y verbal, en la atención selectiva y sustentada, en las funciones ejecutivas, en la fluidez verbal semántica, en las funciones visuoperceptivas y en la velocidad de procesamiento.

Palabras clave: evaluación neuropsicológica, trastornos del lenguaje

The concept of Specific Language Impairment (SLI) has been defined as a primary language deficit that occurs in the absence of hearing loss, deficit in cognitive development or motor speech development, syndromes, pervasive developmental disorders, neurosensory disorders or acquired neurological injuries, which impede the normal development of language (Fresneda & Mendoza, 2005).

In recent years SLI has been approached from a neuropsychological perspective, that is, SLI has been associated with neuropsychological difficulties (Crespo-Eguílaz & Narbona, 2006; Muñoz-López & Carballo, 2005; Rapin, Dunn, & Allen, 2003). However, it seems there is no general dysfunction for SLI, but various skills that may present deficits, such as attention, perception, memory, and executive and visual perceptual functions (Arboleda-Ramírez et al., 2007; Buiza-Navarrete, Adrian-Torres, & González-Sánchez, 2007; Crespo-Eguílaz & Narbona, 2006; Korkman, Kirk, & Kemp, 1998; Muñoz-López & Carballo, 2005).

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Among the deficits mentioned, mnemonic impairment seems to be a good marker of SLI, and a deficit in verbal memory is one of the common denominators in this condition. Nonetheless, even though these children present good non-verbal skills, deficits in visual memory tasks, as reported in some studies (Buiza-Navarrete et al., 2007; Evans, Selinger, & Pollak, 2011; Hick, Botting, & Conti-Ramsden, 2005a, 2005b; Marton, 2008; Menezes, Takiuchi, & Befi-Lopes, 2007), should be taken into account because they suggest visual cues are not being used to help the development of verbal aspects, as occurs in children with normal development. Indeed, the results of some studies, though some are contradictory, seem to indicate difficulties in tasks in which stimuli are complex and/or in which there is a spatial dimension (Buiza-Navarrete et al., 2007; Hick et al., 2005a, 2005b; Marton, 2008; Menezes et al., 2007).

Studies addressing verbal memory report that children with SLI obtain poorer results when compared to control groups (Hick et al., 2005a, 2005b; Muñoz-López & Carballo, 2005). Notwithstanding the fact that verbal memory is one of the most studied fields within SLI, narrative memory has been neglected. The only study found addressing narrative memory (Dodwell & Bavin, 2008) indicates deficiency in the processing, integration and maintenance of auditory information in children with SLI.

The results of studies addressing attention span among children with SLI are far from conclusive, as the case of sustained attention illustrates. The studies by Buiza-Navarrete et al. (2007) and Korkman et al. (1998) report there is a deficit in sustained attention, while Hanson and Montgomery (2002) do not. It is seems possible that these children perform similarly to their peers in certain types of attention but present greater difficulties in others (especially selective auditory attention) (Noterdaeme, Amorosa, Mildenberger, Sitter, & Minow, 2000; Rapin et al., 2003). It is also possible that their attention abilities vary according to the stimuli presented and the demands inherent to the tasks (Spaulding, Plante, & Vance, 2008).

In regard to *executive functions*, some studies (Buiza-Navarrete et al., 2007; Im-Bolter, Johnson, & Pascual-Leone, 2006; Marton, 2008) concluded there is a possibility of deficits, especially at the level of the inhibition of responses, organization and planning strategies that are intended for problem solving. However, we note that the empirical basis related to executive functions in children with SLI is restricted and that its results are not always consistent (Arboleda-Ramírez et al., 2007).

In the domain of *visual perception*, studies (Akshoomoff, Stiles, & Wulfeck, 2006; Buiza-Navarrete et al., 2007; Marton, 2008; Zelaznik & Goffman, 2010) report difficulties, especially in complex tasks that require the simultaneous activation of attention processes, visual discrimination and temporal perception (Buiza-Navarrete et al., 2007) or planning and spatial perception (Akshoomoff et al., 2006). In the last (visual spatial processing tasks) the strategy adopted and global performance show an immature and less efficient approach (Akshoomoff et al., 2006).

The controversy around the neuropsychological characterization of SLI remains open because we face: (1) a highly heterogeneous disorder, regarding which it is difficult to delimitate deficits; (2) there is a paucity of studies; and (3) the results available are very discordant.

This study's objective is to contribute to the clarification of this controversy. Specifically, its main objective is to characterize the neuropsychological profile of children with SLI in the visual and verbal memory areas, attention and executive functions, and visual perceptual functions. For that, some tests from the Coimbra's Neuropsychological Assessment Battery (BANC) were applied both to a group of children with SLI and a group of children without any identified problem.

Based on the current empirical basis, the following hypotheses are proposed:

H1: Children with SLI present deficits in a visual memory test in which the stimulus is complex, as is the case of the Rey Complex Figure test (Buiza-Navarrete et al., 2007; Hick et al., 2005a, 2005b; Marton, 2008), but not in the Memory for Faces test (Korkman et al., 1998).

H2: Children with SLI present verbal memory deficits, evaluated through the Narrative Memory test (Dodwell & Bavin, 2008), when compared to the control group.

H3: Children with SLI present deficits in attention tests (Buiza-Navarrete et al., 2007; Korkman et al., 1998; Rapin et al., 2003) when compared to the control group.

H4: Children with SLI present deficits on instruments evaluating executive functions or executive functions and language in comparison to individuals from the control group (Buiza-Navarrete et al., 2007; Im-Bolter et al., 2006; Marton, 2008). In relation to this hypothesis, we add that the multidimensional nature of the executive system was considered. Some executive functions were analyzed in isolation through the Coimbra's Tower test; the executive functions were jointly analyzed with divided attention on the Trail Making Test B, and with language in the Rapid Naming of Digits test and in the Rapid Naming of Shapes and Colors test, and in the Semantic and Phonemic Verbal Fluency tests.

H5: Children with SLI present deficits in the visual perceptual domain, evaluated through the copy of the Rey Complex Figure test, when compared to children without SLI (Akshoomoff et al., 2006; Buiza-Navarrete et al., 2007; Marton, 2008).

Method

Participants

The group of children with SLI was selected from the *Leiria* and *Santarém* districts, Portugal, in hospitals and schools, particularly those providing speech-language therapy, between December 2008 and March 2009. All the parents provided informed consent for their children to participate in the study.

Children identified by speech therapists or psychologists, with results on standardized language tests corresponding to at least 12 months below their chronological age (Stark & Tallal, 1981) were selected for the study. Considering criteria used to identify SLI (Fresneda & Mendoza, 2005; Stark & Tallal, 1981), children who presented the following conditions were not included: (1) hearing deficit above 25 dB; (2) information provided by the teacher or parents concerning the existence of significant emotional or behavioral problems; (3) cognitive deficit reported by a psychologist or assessment team (based on a IQ <85, obtained on the Wechsler Intelligent Scale for Children, 3rd Edition), or (4) apparent neurological deficit.

Children in this group were matched with children with no history of SLI, selected from the standardization sample of BANC, through matching case-by-case, according to age, gender, socioeconomic level and demographic area.

The sample was composed of 56 children and adolescents, 28 in each matched group, of which 13 were females and 15 were males. Ages ranged from six to 15 years old, with an average of 8.07 years old and a standard deviation of 2.33 years. The groups presented the same distribution in terms of socioeconomic level (based on the professions and academic degrees of both parents) and area of residence, which were mainly low income (53.57%) and urban areas (64.29%).

In regard to schooling, the sample was composed of children enrolled from the 1st to the 10th grade. The groups did not present statistically significant differences (t (54) = -0.851, p = 0.398) in this respect, though repetition of grade levels was most frequently observed among children with SLI. Eight (28.57%) children with SLI had already failed at least one year, while the remaining 20 (71.43%) had never failed, nor had any of those in the control group. This difference is statistically significant in relation to the control group according to Fisher's Exact test (p = .002). The entire group of children with SLI attended speech therapy for a period of one to four years, with an average of 1.79 (SD = .99) years.

Instruments

BANC (Simões et al., 2008) is a battery of tests for neuropsychological evaluation that enables the assessment of neurocognitive functioning of Portuguese children and adolescents, aged between five and 15 years old. It was adapted and standardized in a sample of 1,104 children and adolescents and has diversified evidence for the adequacy of its psychometric properties. Of the tests that compose it, the following eight were selected based on the aforementioned hypotheses.

The *Narrative Memory* test assesses one's ability to learn, retain, recall and recognize auditory and verbal material, as well as one's planning, organization, sequencing, comprehension and expression. The examiner reads two stories and the child has to retell the story immediately after listening to each of them (Immediate Recall). Twenty or thirty minutes later, the child is asked to retell once more each of the two stories previously presented (Delayed Recall) and answer a series of related multi-choice questions (Recognition). There are two versions of this test. One is applied to children 6 to 9 years old (Stories A and B) and the other is applied to children 10 to 15 years old (Stories C and D). Hence, three different scores are obtained: Immediate Recall, Delayed Recall, and Recognition.

The *Memory for Faces* test assesses visual-perceptual aspects and the recognition of faces. A total of 16 faces are presented in the learning trial, each for three seconds. Then, 16 series with three faces are presented, each for five seconds, in the Immediate and Delayed Recall trials. After all the learning items are presented, the child has to choose the face s/he saw during the learning from series of three faces each (Immediate Recall). After an interval of 20 to 30 minutes, the child is asked to identify the same faces again (Delayed Recall). Three different scores are also obtained in this test: Immediate Recall, Delayed Recall, and Total.

The *Rey Complex Figure* test assesses visual-spatial and constructive processes, visual memory and executive functions (e.g. planning and problem-solving). The child is asked to observe a geometric figure and copy it onto a white sheet (Copy). Three minutes after s/he has to reproduce the figure by memory (Immediate Recall), and this task is repeated 20 to 30 minutes later (Delayed Recall). A score is computed for each of the three tasks performed in this test (Copy, Immediate Recall and Delayed Recall). The quality of reproduction and type of errors committed were taken into account in the task "Copy".

The *2 and 3 Signs Cancellation test* measures selective attention and sustained attention. It also requires the ability to visually explore with accuracy, to activate and inhibit rapid responses (Korkman et al., 1998). It is composed of two A3 sheets with 1,600 squares (40 lines, with 40 squares each), of which, only 10 or 15 squares in each line (depending on whether it is the 2 or 3 Signs Cancellation) are equal to one of the models. The child's task is to cross out the target squares within a period of 10 minutes. There are two versions of this test, one applied to children 6 to 9 years old (2 Signs) and another for children aged 10 to 15 years (3 Signs). The total score is computed through a formula that takes into account the number of correct answers, gaps and errors.

The *Trail Making Test* assesses selective attention (Part A), divided attention (Part B) and motor speed. It is composed of two parts: Part A is applied to 5 to 15 year-old children and Part B is applied to children 7 years old or older. In the part

A, the child draws (with pencil) a line that connects the 25 numbered circles (randomly distributed on the sheet), according to appropriate order, from one to 25. In part B, the child has to draw a line that connects the 25 circles with numbers or letters (randomly distributed on the sheet), alternating numbers and letters (connecting 1 to A, 2 to B, etc.). As one can see, Part B is more complex than Part A because it requires flexibility mechanisms and cognitive shifting. Two types of scores are obtained in each of the two parts of this test: number of errors and time required to complete the task.

The *Coimbra's Tower test* assesses the child's executive functions, namely the abilities to plan, monitor, self-regulate and solve problems (Korkman et al., 1998). The child has to reproduce 12 to 14 different models in a tower, moving three colored balls, following three rules: (1) each pin of the tower contains only one given number of balls; (2) the child should move one ball at a time; and (3) each problem has a maximum number of movements allowed. Whenever any of these rules is broken, it is considered that the individual has committed one error (type I, type II or type III, respectively). The following scores were computed in this test: total number of models successfully reproduced in the first trial; total number of correctly solved problems; total number of trials performed; number of times the rules were violated; planning time; and planning time in the case of correct problems.

Semantic and Phonemic Verbal Fluency assess one's ability to generate words according to two categories: phonemic and semantic. In the phonemic category, the child should list the maximum number of words starting with the letters "P", "M" and "R" in trials of one minute per letter. In the semantic category, also within periods of one minute, the child should recall "names of animals", "names of boys and girls" and "names of foods". Only the Semantic Verbal Fluency test is applied to children aged 5 to 6 years old. The scores correspond to the number of correct words.

The *Rapid Naming of Digits* and of *Shapes and Colors* tests are designed for children 7 to 15 years old and assesses one's ability to rapidly access and produce familiar words, naming items by their shape and color (Rapid Naming of Shapes and Colors test) and by their name (Rapid Naming of Digits test). The second test calls for a single semantic category while the first test calls for two semantic categories. For this reason, the first is considered more complex in terms of the competencies it evaluates. In any of the tests, the child is asked to name, as fast as possible, 50 visual stimuli printed on a card, which are repeated in random sequences. The scores refer to the total time spent to complete the task and the number of errors.

Procedure

Data collection. The tests were applied individually in a peaceful environment in two sessions of approximately 45 minutes. The order in which the tests were administered was: 1st session – Immediate Recall of Memory for Faces, Immediate Recall of Narrative Memory, Rapid Naming tests, Semantic and Phonemic Verbal Fluency, Delayed Recall of Memory for Faces, 2 and 3 Signs Cancellation test, Delayed Recall and Recognition of Narrative Memory; 2nd session – Copy of the Rey Complex Figure, Part A of the Trail Making Test, Immediate Recall of the Rey Complex Figure, Part B of the Trail Making Test, Coimbra's Tower, Delayed Recall of Rey Complex Figure. The paper's primary author performed the application and scoring of tests under the supervision of the second author.

Data analysis. The statistical analyses were performed in the Statistical Package for the Social Science (SPSS, version 16). After testing the distribution of variables with the Shapiro-Wilk test, it was observed that most of the variables did not present a normal distribution. Therefore, in these cases, the nonparametric Mann-Whitney U test was selected; the Student's t-test was used in the remaining cases. Homoscedasticity was assessed with Levene's test and Satterthwaite's correction was considered whenever necessary.

Results

Memory

Significant differences were found between the groups in the visual memory tests (Table 1) in relation to immediate recall and delayed recall. Distinct results were found in both versions of the *Narrative Memory* test (Table 1). Statistical significance was found between the two groups in relation to the test's three scores among children 6 to 9 years old. No statistically significant differences were found in the group of children aged from 10 to 15 years old, though the average scores obtained by the children with SLI were below those obtained by the control group. Note, however, that this was a very small subsample ($n = 6$).

Attention and Executive Functions

The standardized scores obtained by the children with SLI were lower than the scores obtained by their counterparts in the tests of attention and executive functions (Table 2). Two types of results were observed on the *Cancellation* test, according to the children's age. The groups differed significantly in relation to the total score and number of correct signs in the 2 Signs Cancellation; such differences were not found in relation to the 3 Signs Cancellation.

In regard to errors, the groups differed significantly only in relation to gaps in the 2 Signs Cancellation. Nonetheless, we note that the number of errors was higher in the group with SLI for all of the test's versions and that very wide standard deviations were observed in the gaps and errors of the 2 Signs Cancellation test.

Table 1
Comparisons Between the Groups in Visual and Verbal Memory Tests

	SLI		Control		t/U	p
	M	*SD*	*M*	*SD*		
Rey Complex Figure						
Immediate Recall	5.61	2.57	9.96	3.18	115.50	.000**
Delayed Recall	5.14	2.82	9.64	2.84	-5.940[a]	.000**
Memory for Faces						
Immediate Recall	8.32	3.58	10.68	2.29	249.00	.018*
Delayed Recall	8.07	3.14	10.25	2.03	225.50	.006**
Total (Immediate+Delayed)	8.04	3.53	10.57	1.97	224.50	.006**
Narrative Memory (6 to 9 years old) (*n* = 22)						
Immediate Recall	7.14	2.66	9.27	2.73	-2.630[a]	.012*
Delayed Recall	7.68	2.51	9.64	2.30	138.50	.014*
Recognition	5.91	3.69	9.50	2.86	-3.609[a]	.001**
Narrative Memory (10 to 15 years old) (*n* = 6)						
Immediate Recall	6.50	3.62	11.00	3.10	7.00	.076
Delayed Recall	6.50	3.78	10.50	4.14	7.00	.076
Recognition	6.00	4.69	9.83	4.36	9.50	.172

Note. [a]Student *t*. *$p < .05$; **$p < .01$

The children with SLI differed significantly from the control group on *Trail Making Test A* in relation to the errors committed, but not in relation to how fast they completed the test, though they obtained poorer scores compared to the control group.

On *Trail Making Test B,* a more complex test, the groups differed in terms of time spent to complete the task. The children with SLI were slower and also committed more errors.

The children with SLI obtained significantly poorer scores on *Coimbra's Tower* test, in relation to the number of problems correctly solved in the first trial, the total number of problems solved and planning time. In regard to the errors committed, the groups did not differ in type I and type II errors, though the differences were statistically significant in relation to type III errors. This last result indicates that the children with SLI exceeded the number of movements allowed for completing the task. The two groups also differed significantly in terms of the total number of errors.

Language and Executive Functions

The clinical group obtained significantly poorer results in the Rapid Naming tests both in terms of time spent and errors. This group also obtained significantly poorer results on a *Verbal Fluency* test, more specifically in Semantic Verbal Fluency. The differences are not significant in Phonemic Fluency, though the average performance of the clinical group was below the average performance of the control group.

Visual Perceptual Functions

The visual perceptual functions were assessed through the *Rey Complex Figure* test (Table 4) and the performance of the clinical group was significantly poorer than that of the control group. The group of children with SLI committed more errors, of both rotation and confabulation (adding elements to the figure), in their reproductions. Even though not statistically significant, the clinical group committed more convergence errors (the use of a line to represent more than one element of the figure) and preservation (repetition of an element).

In regard to the type of copy, the group of children with SLI opted, in a number significantly higher (χ^2 (54) = 14.27, p = .000) for type II of copy, while the control group opted, in a number significantly higher (χ^2 (54) = 23.52, p =.000), for type IV. In other words, many children with SLI began the copy by a detail contiguous to the rectangle, while most children in the control group drew the details of the figure next to each other.

Discussion

In general, the tests indicated deficits in the neuropsychological functioning of children with SLI in relation to their peers, namely: visual memory of stimuli with different degrees of complexity, narrative memory, selective and sustained attention, executive functions, semantic verbal fluency, visual perceptual functions and processing speed.

Table 2
Comparisons Between the Groups in Attention/Executive Functions Tests

	SLI			Control			t/U	p
	n	*M*	*SD*	*n*	*M*	*SD*		
Signs Cancellation								
Total	22	5.86	3.27	22	9.68	3.27	-4.127[a]	.000**
Correct answers[b]	22	56.77	25.35	22	88.86	26.69	-4.809 [a]	.000**
Gaps[b]	22	20.77	20.42	22	12.68	9.87	157.50	.047*
Errors[b]	22	8.18	17.74	22	1.91	2.45	165.00	.066
Signs Cancellation								
Total	6	4.50	3.39	6	8.83	2.86	6.00 [a]	.051
Correct answers[b]	6	125.17	48.06	6	170.50	57.17	11.50 [a]	.297
Gaps[b]	6	19.83	12.89	6	18.67	14.91	16.00 [a]	.749
Errors[b]	6	2.50	2.26	6	1.00	.89	11.00	.249
Trail Making Test A								
Time	28	7.32	3.50	28	8.89	3.18	-1.760 [a]	.084
Errors [b]	28	1.75	1.90	28	.18	.39	194.00	.006**
Trail Making Test B								
Time	20	7.00	3.60	20	9.85	3.47	103.00	.006**
Errors [b]	20	2.70	2.90	20	.40	.75	74.00	.000**
Coimbra's Tower								
Correct Problems- 1st trial	28	8.00	3.27	28	11.04	3.33	-3.445 [a]	.001**
Correct Problems-Total	28	9.21	2.41	28	11.00	3.02	258.00	.027*
Number of trials	28	9.61	3.56	28	11.32	3.37	277.00	.058
Errors Type I[b]	28	.29	.71	28	.07	.26	348.00	.209
Errors Type II[b]	28	.75	1.21	28	.64	1.10	380.50	.829
Errors Type III[b]	28	9.29	4.45	28	6.46	3.84	242.50	.014*
Total Error[s]	28	10.32	4.13	28	7.18	4.23	221.00	.000**
Planning time[b]	28	17.54	9.74	28	63.86	37.44	41.00	.000**
Planning time Correct Problems Correct answers[b]	28	1.34	.74	28	4.72	2.64	44.50	.000**

Note. [a]Student t. [b]raw scores. *$p < .05$; **$p < .01$

Table 3
Comparisons Between the Groups in the Language and Executive Functions Domains

	SLI			Control			t/U	p
	n	*M*	*SD*	*n*	*M*	*SD*		
Rapid Naming								
Shapes and Colors - Time	20	5.25	3.80	20	9.30	3.81	89.50	.003**
Shapes and Colors - Error [b]	20	8.50	8.37	20	1.30	1.66	75.00	.001**
Digits – Time	20	5.05	4.38	20	10.80	2.97	59.50	.000**
Digits – Error [b]	20	1.25	2.81	20	.00	.00	140.00	.009**
Verbal Fluency								
Phonemic	20	8.60	2.68	20	10.05	3.41	-1.494[a]	.143
Phonemic P[b]	20	4.10	1.59	20	5.80	3.71	150.00	.170
Phonemic R[b]	20	3.65	2.25	20	5.15	3.08	141.50	.110
Phonemic M[b]	20	4.55	1.50	20	4.95	3.17	192.50	.836
Semantic	28	6.18	2.04	28	9.46	3.60	172.50	.000**
Semantic Animals	28	7.57	2.47	28	11.86	3.88	141.00	.000**
Semantic FOOD[b]	28	7.79	1.85	28	10.61	4.37	228.50	.007**
Semantic BOYS/GIRLS[b]	28	10.46	3.36	28	13.79	5.79	262.50	.033*
Verbal Fluency Total	20	6.05	2.37	20	9.75	3.93	-3.603[a]	.001**

Note. [a]Student *t*. [b]raw scores. *$p < .05$; **$p < .01$

Table 4
Comparisons Between the Groups in the Visual-Perceptual Functions Domain

	SLI (n = 28)		Control (n = 28)		U	p
	M	SD	M	SD		
Rey Complex Figure						
Copy	3.93	2.62	10.00	2.94	-8.147	.000**
Rotation errors[a]	3.54	2.27	2.25	2. 49	253.50	.022*
Preservation errors[a]	3.21	2.10	3.36	2.34	378.50	.823
Convergence errors[a]	1.32	1.02	1.64	1.97	383.50	.886
Confabulation errors[a]	3.79	2.33	.50	1.00	66.50	.000**

Note. [a]raw scores. *p < .05; **p < .01

In the domain *visual memory*, the group with SLI obtained statistically significant poorer scores in all trials, which suggests difficulties in the recall process and visual encoding. The results in the Memory for Faces are not in agreement with those reported by the only study we found that addressed it in children with SLI (Korkman et al., 1998) and that did not find statistically significant differences. This study's results suggest that the children with SLI present difficulties in operating visual stimuli, whether complex or simple, as is the case of the Rey Complex Figure and Memory for Faces, respectively. These findings are in agreement with some studies (Buiza-Navarrete et al., 2007; Hick et al., 2005a, 2005b; Marton, 2008; Menezes et al., 2007) that showed that children with SLI have a disadvantage in tasks with complex stimuli. In summary, the results found in this study partially support our first hypothesis (H1).

The difficulties found in *verbal memory* were significant in all the trials performed by the group of children 6 to 9 years old but not in the 10 to 15 years old group. As previously stated, though, the results concerning the second group may have been conditioned by the group's size. The difficulties in the group with SLI seem to emerge right at encoding the verbal information, as the poorer results obtained in the immediate recall in the Narrative Memory test reflect. The comparison between immediate and delayed recall does not indicate there was loss of information.

Since difficulties were observed both in relation to recall and recognition, this represents additional evidence indicating that the children's difficulties may be related to information encoding, that is, since information is not properly encoded, it is difficult to access it, regardless of the conditions under which it is requested. In our view, problems in encoding processes in the SLI group may be related to verbal working memory and processing of auditory information.

Nonetheless, since both recall and recognition are affected, one cannot discard the possibility that poor performance is due to attention deficits, comprehension problems or reduced interest in the task, especially because memory problems among children are often secondary to deficits in other cognitive domains or to emotional factors.

This study's results confirm the hypothesis of the existence of deficits in the verbal memory of children with SLI (H2), which is in agreement with the results of other investigations (Hick et al., 2005a; Muñoz-López & Carballo, 2005). Additionally, the results obtained here broaden and corroborate the reduced empirical basis related to the use of stories in the study of verbal memory deficits among children with SLI.

The analysis of results obtained at the level of *attention span* indicates that children with SLI have limited sustained and divided attention. In the case of the 2 Signs Cancellation test, the deficit seems to be a consequence of not being able to remain attentive in an efficient manner during the course of the task. The deficit may also derive from a slower rhythm in performing the task or processing information, as shown by the lower number of correct answers and also by a significantly higher number of gaps.

These results converge with sustained attention problems among children with SLI, as demonstrated in the literature (Buiza-Navarrete et al., 2007; Korkman et al., 1998), even though not unanimously (Hanson & Montgomery, 2002). In this regard, we must consider the possibility proposed by Spaulding et al. (2008), according to whom, inconsistency in the empirical data may be rooted on the differential demands of the instruments used to assess attention. Hence, when the demands of tasks are reduced, children with SLI may have sufficient resources, at the level of attention span, to perform successfully. The contrary would happen when tasks become more difficult, as observed in the 2 Signs Cancellation test. Another way to interpret the inconsistency of empirical data is related to the fact that there is heterogeneity of deficits that may emerge in association with this disorder, specifically comorbidities between SLI and attention deficits (Willinger et al., 2003).

Regarding selective attention as evaluated by the *Trail Making Test* (Parts A and B), significant differences were found between the two groups in the errors made and in relation to the time spent (Part B). Even though some studies detected differences at this level among children with SLI (Noterdaeme et al., 2000; Rapin et al., 2003), they refer to auditory stimuli rather than to visual stimuli such as those included in this test. In synthesis, the differences between the two groups in attention functions were significant, confirming the third hypothesis (H3).

In what concerns *executive functions,* the children with SLI differed from their peers, as evidenced by the poorer results obtained, namely in cognitive flexibility ability, planning, problem-solving, and inhibition of behavior, as the results obtained on the Coimbra's Tower test show. In turn, the significantly higher number of errors of type III reflects a lack of planning, while the significantly higher number of errors may be related to difficulties of monitoring performance, to deficits in simultaneous information processing, or in maintaining the rules in their working memory.

As previously noted, the time spent on the Part B of the *Trail Making Test* and the number of errors obtained diverge significantly between the two groups. The children with SLI were slower and committed more errors, a fact that shows difficulties at the level of planning, shifting, and behavioral inhibition abilities. Nevertheless, since Part B of the *Trail Making* test simultaneously assesses divided attention and executive functions, it is not possible to specifically determine which of these present difficulties in children with SLI.

Also in the sphere of *language* and *executive functions*, significant deficits were found in the Rapid Naming of Digits and of Shapes and Colors, in Semantic Verbal Fluency and in Total Verbal Fluency.

Research indicates that children with SLI have difficulties in recalling words (Lahey, Edwards, & Munson, 2001; Wiig, Zureich, & Chan, 2000), tend to be slower at doing it (Lahey et al., 2001; Wiig et al., 2000), and commit a larger number of errors (Lahey & Edwards, 1999). The results obtained in the Rapid Naming tests corroborate these observations both in relation to slowness and inaccuracy. A study performed by Wiig et al. (2000) reports that the test of Rapid Naming of Shapes and Colors more efficiently differentiates children with and without SLI than does the Rapid Naming of Colors or Shapes only. However, the present study did not find any differentiating power of the test of Rapid Naming of Shapes and Colors in comparison with the test of Rapid Naming of Digits. In any case, and given the fact that dissociations have been observed in other clinical groups depending on the stimuli provided, exploring the impact of the alphanumeric or non-alphanumeric nature of stimuli on the performance of this population is relevant.

The group with SLI also presented difficulties in another domain of linguistic and executive functions, that of (semantic and total) verbal fluency, though no significant differences were found between the groups on the Phonemic Verbal Fluency test (although the group with SLI produced fewer words than the control group). The lower recall rate of words may be associated with a difficulty in accessing the memory system, with a problem of speech production, with deficits in applying effective strategies, with forgetting initial instructions, or with an inability to monitor one's own answers (Simões et al., 2007). In the case of SLI, the difficulty may also lie in poor representations of words in memory in terms of robustness and diversity of the respective associations. In this study, the analysis of answers confirms that the difficulties of the children with SLI are mainly associated with the production of words that did not fit into the categories requested and/or with a lack of monitoring of answers (repetition of words already provided). Both observations are compatible with difficulties at the level of recall and representations, as well as with self-regulation deficits.

The average results obtained by the group of children with SLI in the Phonemic Fluency test did not significantly differ from those obtained by the control group. These results are contrary to what was expected and they are difficult to explain (Weckerly, Wulfeck, & Reilly, 2001), though we do advance two non-mutually exclusive hypotheses. The first points to the fact that this is a group who attends speech-language therapy and more than half the children (*n=16*) have already attended the two first years of school. Activities of a phonological nature are common in both contexts, which would be a facilitator condition.

Secondly, we recall the study conducted with NEPSY (Korkman et al., 1998), which reported that children with SLI presented results similar to the control group in Verbal Fluency, a fact that, according to the authors, suggests the possibility of subgroups with different degrees of difficulty within the larger SLI group. In our opinion, this interpretative possibility is also extended to the group with SLI addressed in this study.

In summary, the groups differ in the results of the instruments that assess executive functions in isolation or together with divided attention and language. These findings confirm, in part, one of our hypotheses (H4), since no significant differences were found in relation to the Phonemic Verbal Fluency.

Additionally, slow performance is observed for all the assessment instruments used in this study that required speed (Trail Making Test A e B, Rapid Naming of Digits and of Shapes and Colors, Semantic and Phonemic Verbal Fluency). Given the multidimensional nature of many of these instruments, indirect support is provided to a hypothesis that has been proposed in relation to SLI and that indicates slow linguistic and non-linguistic information processing speed (Lahey et al., 2001).

The results obtained on the visual-perceptual domain, through the copy of the Rey Complex Figure, are in agreement with published research (Akshoomoff et al., 2006; Marton, 2008; Buiza-Navarrete et al., 2007) reporting significant differences between the visual-spatial perceptions of children with SLI and those without SLI. Among these studies, the one performed by Akshoomoff et al. (2006), deserves a special note, because it used the Rey Complex Figure test and, as the present study, found a lower accuracy in the reproduction of different elements in the figure on the part of the group with SLI.

Additionally, Akshoomoff et al. (2006) observed the adoption of a more immature and fragmented strategy in the copy of the figure, which, from the authors' perspective, indicates a more general deficit of attention and planning. Such a finding, concerning the type of copy adopted, was not found in this study, since, even though most children in the group with SLI used the type II and most in the control group used the type IV, both types of copy are expected among children these ages (Rey, 1988). Nonetheless, children with SLI presented a significantly higher number of confabulation (addition of an element to the figure) errors, which in our perspective, is in agreement with the report of Akshoomoff et al. (2006). Planning and paying attention to a lesser degree, the children with SLI may not have sufficiently monitored the accuracy of their copy in relation to the model, adding elements there were not actually present. In turn, the significantly higher number of rotation errors (45 degrees or more degrees of rotation of any line segment or element), even though may have originated in these factors, may equally reveal deficits at the level of spatial perception. In summary, our hypothesis (H5) that the group of children with SLI would reveal deficits in the visual-perceptual domain when compared to children without SLI was confirmed.

Some limitations of this study should be noted. First, we acknowledge the limitations concerning the assessment instruments used, since we did not use all the tests from BANC. Additionally, the samples are very small in some of the tests' versions (Narrative Memory from 10 to 15 years old and the 3 Signs Cancellation test). We also point out the fact that various tests used, such as the Rey Complex Figure test, Narrative Memory test, Trail Making Test and Verbal Fluency tests, simultaneously assess various processes, and therefore, it is impossible to precisely determine which process or processes are deficient in the SLI group.

Another limitation is related to the identification of SLI, specifically the use of comprehensive language tests standardized for the Portuguese population, since there is a lack of such assessment instruments in Portugal. Even though this is unavoidable at the moment, we acknowledge it is an important obstacle to any Portuguese investigation addressing SLI. Another limitation is related to the fact that all members in the SLI group attended speech-language therapy.

Final Considerations

Data obtained in this study confirm a large part of the hypotheses initially proposed, which foresaw that poorer results would be obtained by children with SLI in the BANC tests when compared to a control group. We gathered evidence that the deficits in SLI are not exclusively linguistic deficits; they are not restricted to the phonological or auditory processing and, therefore, should be seen from a broader perspective.

The BANC tests selected are a valid tool to make the neuropsychological characterization of children with SLI, and may be applied in various contexts, such as clinics, speech therapy, and psycho-pedagogy. In any case, future studies can contribute to consolidate the reliability of these indicators in the evolution of SLI and also help to devise intervention programs directed to this pathology (Rolfsen & Martinez, 2008).

We also note the great heterogeneity of the SLI group of children and the consequent importance of delineating specific subgroups. Therefore, we believe that reevaluating the results presented here using larger and more homogeneous samples would be relevant in future research.

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