Neuropsychological aspects of 10-year-old children

Aspectos neuropsicológicos de crianças de 10 anos de idade

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ABSTRACT

Objective: To characterize neuropsychological aspects of 10-year-old children. **Method:** Out of 30 children, 26 cognitively normal 10-year-old public school students answered tests extracted from Luria-Nebraska Neuropsychological Battery: Children's Revision. The study was transversal. Descriptive and inferential statistical analysis were carried out. **Results:** Most of the 10-year-old children retold a story (69.2%), understood it making correct inference (84.6%) and reproduced it adequately in writing (76.9%) – 14.9% was the average number of incorrectly written words and 0.179 was the errors per written word coefficient. Besides, 53.8% showed logical thought process and 73.1% had a correct notion of "x more than…". They got five out of eight in the visuo-spatial test, an intermediary result. These results show that the tertiary areas of units II and III are developed in most 10-year-old children. The most frequent types of written mistakes were: oral influence (26.3%), multiple representation (22.5%) and omission (18.4%). As to coding principles, the mostly uncomplied with rule was vowel nasalization at end of syllable (23,53%). **Conclusions:** Ten-year-old children in the studied population understood and reproduced a story orally and in writing with a low coefficient error/word. The majority completed the visuo-spatial tests and presented logical thought process. When "x more than…" notion is absent it may be an indicator that all is not well in the reading/writing process.

Keywords: Language tests; Comprehension; Visual perception; Space perception; Child

RESUMO

Objetivo: Caracterizar os aspectos neuropsicológicos de crianças de 10 anos. **Métodos:** De um total de 30 crianças, 26 estudantes de 10 anos de escola pública, que haviam se revelado cognitivamente adequados nas Matrizes Progressivas de Raven, responderam a questões extraídas e adaptadas da Bateria Neuropsicológica Luria-Nebraska: Versão Infantil. O estudo foi transversal. Foi usada análise estatística descritiva e inferencial. **Resultados:** A maioria das crianças recontou a história (69,2%), fez sua inferência mostrando tê-la compreendido (84,6%) e a reproduziu adequadamente por escrito (76,9%). Em média, apresentaram 14,9% de palavras escritas incorretamente e coeficiente de 0,179 erros/palavra escrita. Além disso, 53,8% tiveram raciocínio lógico e 73,1% tinham uma noção de "a mais". Responderam cinco de oito no teste visuo-espacial, sendo este um resultado intermediário. Esse desempenho atesta que, aos dez anos, as áreas terciárias da unidade II e III, estão desenvolvidas na maioria das crianças. Tipos de erros grafêmicos mais frequentes: oralidade (26,3%), representação múltipla (22,5%) e omissão (18,4%). A regra referente à nasalização da vogal em final de sílaba não final de vocábulo foi a mais desrespeitada (23,53%). **Conclusão:** Estudantes de 10 anos da população estudada compreenderam e reproduziram oralmente e por escrito uma história com baixo coeficiente de erros/palavra escrita. A maioria respondeu à prova visuo-espacial e apresentou raciocínio lógico. A ausência de noção de "a mais" pode ser um preditor de inadequação de leitura/escrita.

Descritores: Testes de linguagem; Compreensão; Percepção visual; Percepção espacial; Criança

INTRODUCTION

This is a small set of tests extracted from the Luria-Nebraska Neuropsychological Battery-Children's Revision (LNNB-C)[1], which proved especially sensitive in identifying language alterations and has been used for about 17 years in a Speech Therapy Service of a public hospital for individuals of different ages and levels of schooling with complaints of difficulties in oral and/or written language. The tests are based on Luria's neuropsychological approach[2], which was validated by modern techniques, such as those of Bhimani et al.[3].

Study carried out at Escola Paulista de Medicina, Universidade Federal de São Paulo – UNIFESP, São Paulo (SP), Brazil.

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Knowledge of the linguistic and verbal performance of cognitively normal children may show the process of neuromaturation in the 10-year-old age group. This knowledge may contribute towards the health of the child and its quality of life, as it will allow the clinician to outline the development profile that will direct treatment over the rehabilitation process. Such considerations justify the present study.

OBJECTIVE

To characterize the neuropsychological aspects of 10-year-old children, who are students at a public school.

METHODS

This cross-sectional study was carried out at the Department of Speech Therapy of the *Escola Paulista de Medicina da Universidade Federal de São Paulo* (UNIFESP), from 2008 to 2012, having been approved by the Research Ethics Committee (CEP) of the institution under protocol number 0986/09. The persons in charge of the participants signed informed consent forms.

The inclusion criterion was to be cognitively adequate on the progressive Matrices of Raven[4]. Excluded were children who presented with evidence of neurological and/or psychiatric alterations.

The procedures utilized Raven's Progressive Matrices[4] and a few tests extracted from LNNB-C[3] and from Jean Piaget[5,6]'s work, slightly modified or amplified[7].

The 30 children aged 10 years, from the 4th grade of a public school, were asked by an experienced psychologist to fill in the Raven's Progressive Matrices, with the objective of evaluating their intelligence; 26 of them showed adequate cognition and individually responded to the following neuropsychological tests:

Oral and written reproduction and comprehension of the story "The crow and the doves". Instruction: "I am going to tell you a story and you will repeat what you remember: *A crow heard/that the doves had plenty to eat./ He coloured himself white/ and flew to the dove cote./ The doves thought/ he was one of them/ and took him in./ However, he could not help cawing/ like a crow./ The doves then realized that he was a crow/ and threw him out./ He went back to rejoin the crows,/ but they did not recognize him/ and would not accept him./ Question: " Why did the crows not accept him?"*

The first criterion of adequacy was to reproduce eight (or more) items in reference to the story (beginning, middle, and end).

The criterion of adequacy for understanding the story or making a summarizing inference: to say that he was (painted or wearing) white. The child was asked to write the story. The numbers of written words were counted, and the number and percentage of words written incorrectly and number of written errors of each child were calculated (accent and concordance errors were not considered). The coefficient was calculated by dividing the mean number of errors by the mean number of written words. The written production was considered satisfactory as long as it was coherent and cohesive and had a number of errors that did not exceed the mean of the sample group plus a standard deviation. The qualitative analysis was performed by an independent judge, that used the classification of errors proposed by Zorzi[8,9], and by three judges who based their opinions on the writing codification rules proposed by Scliar-Cabral[10]: C1-rules independent of the context; C2-rules dependent on the position of the phonetic context; C3-competitive alternative; C4-rules dependent on morphosyntax and phonetic context; C5-morphological derivation.

Visual-spatial test. This test analyzed the visual function or the visual-spatial notion with pictures of squares that have a thicker line and a small circle in one of the corners. The number of possible correct answers out of eight possible answers is noted, and the time spent is recorded.

Logical thinking test. Ask: "*If I have three candies and you have one candy more than I do, how many candies do we have together?*" Three coins are placed before the child and two in front of the evaluator. Ask: "*How many more do you have than me?*" With this test, the notion of "more than" is analyzed.

Statistical method

Descriptive statistics for the quantitative variables with sum measurements and the following inferential analyses[11,12]: χ^2 test[13] and Student's *t* test, Pearson and Spearman's coefficient of linear correlation. Level of significance was equal to 5%. Software Statistical Package for Social Sciences (SPSS) software, version 15.0 for Windows and R-Program version 2.9.2 were employed.

RESULTS

The sample was composed of 26 children of 10-years-of-age, where15 (57.7%) was female. Less than half (48.0%) of them lived in a house owned by the family and the monthly family income of most of them was

lower than R$2,125.00. In 2009, these 26 children and their colleagues, with a total of 60 children, obtained the mean result of 204.2 in the Portuguese Language Evaluation[14], similar to that of 1,077,988 children in the 4th grade in the State of São Paulo, which allowed the inference that they are typical. Table 1, shows the values of descriptive statistics of the 26 children in the neuropsychological tests. Children with up to 21.98 errors and coherence in their stories were classified as having adequate writing quality. As to the qualitative study carried out by the judges, the most frequent[8,9] types of written errors were: orality (26.30%) (for example, using *entra* instead of entrar), multiple representation (22.50%) (for example: *pençou* instead of pensou) and omission (18.40%) (for example: *pobas* instead of *pombas*). The writing codification rules[10]

Table 1. Performance of the 10-year-old children on the neuropsychological tests

Aspects evaluated	Descriptive measurements	Male (n=11)	Female (n=15)	Total (n=26)	p value	Power[a]
Total number of written words	Mean	56.64	63.87	60.81	0.084[b]	0.389
	Median	57.00	65.00	63.00		
	Minimum-maximum	35.00-69.00	42.00-91.00	35.00-91.00		
	Standard deviation	9.54	10.46	10.53		
Number of words written incorrectly	Mean	15.00	4.07	8.69	<0.001[b]	0.927
	Median	14.00	3.00	6.50		
	Minimum-maximum	6.00-28.00	0.00-17.00	0.00-28.00		
	Standard deviation	7.04	4.43	7.82		
Percentage of words written incorrectly	Mean	26.6%	6.4%	14.9%	<0.001[b]	0.955
	Median	24.1%	4.7%	11.3%		
	Minimum-maximum	12.7%-43.8%	0.00%-25.8%	0.00%-43.8%		
	Standard deviation	11.6%	6.8%	13.5%		
Number of errors	Mean	18.91	5.07	10.92	0.001[b]	0.862
	Median	18.00	3.00	7.50		
	Minimum-maximum	6.00-44.00	0.00-26.00	0.00-44.00		
	Standard deviation	11.09	6.60	11.06		
Notion of quantity conservation	Yes	11 (100.0%)	14 (93.3%)	25 (96.2%)	>0.999[c]	0.153
	No	-	1 (6.7%)	1 (3.8%)		
Notion of "more than"	Yes	7 (63.6%)	12 (80.0%)	19 (73.1%)	0.407[c]	0.148
	No	4 (36.4%)	3 (20.0%)	7 (26.9%)		
Candies	Yes	4 (36.4%)	10 (66.7%)	14 (53.8%)	0.126[d]	0.322
	No	7 (63.6%)	5 (33.3%)	12 (46.2%)		
Reproduction	Yes	9 (81.8%)	9 (60.0%)	18 (69.2%)	0.395[c]	0.224
	No	2 (18.2%)	6 (40.0%)	8 (30.8%)		
Comprehension of the essence of the story	Yes	10 (90.9%)	12 (80.0%)	22 (84.6%)	0.614[c]	0.107
	No	1 (9.1%)	3 (20.0%)	4 (15.4%)		
Quality of writing	Adequate	8 (72.7%)	12 (80.0%)	20 (76.9%)	>0.999[c]	0.071
	Inadequate	3 (27.3%)	3 (20.0%)	6 (23.1%)		
Number of correct answers on the visual-spatial test	Mean	4.27	6.07	5.31	0.039[b]	0.472
	Median	3.00	6.00	5.00		
	Minimum-maximum	1.00-8.00	3.00-8.00	1.00-8.00		
	Standard deviation	2.33	1.87	2.22		
Time on the visual-spatial test (seconds)[e]	Mean	124.50	114.87	118.72	0.549[b]	0.074
	Median	120.00	100.00	109.00		
	Minimum-maximum	105.00-187.00	62.00-240.00			
	Standard deviation	24.37	45.66	38.24		

[a] Statistical power; [b] Student's *t* test for independent samples; [c] Fisher's exact test or its extension; [d] Person's χ^2 test; [e] the male group in this test had 10 individuals.

Table 2. Estimates of Person's and Spearman's linear correlation coefficients between the number of correct answers on the visual-spatial test and the total number of written words, number of words written incorrectly, percentage of words written incorrectly, number of errors, and time spent on the visual-spatial test

Aspects evaluated	Measurements	Pearson	Spearman
Written words and visual-spatial test	Coefficient	-0.004	-0.107
	p value	0.984	0.601
Words written incorrectly and visual-spatial test	Coefficient	-0.293	-0.349
	p value	0.146	0.080
Words written incorrectly (%) and visual-spatial test	Coefficient	-0.359	-0.329
	p value	0.072	0.101
Errors and visual-spatial test	Coefficient	-0.224	-0.282
	p value	0.272	0.163
Time for visual-spatial test and visual-spatial test	Coefficient	-0.427	-0.578
	p value	0.033	0.002

Table 3. Performance distribution of the children on the tests of quantity conservation, candies, comprehension of the essence of the story, writing quality, visual-spatial test, and time on visual-spatial test, as per the performance on the notion of "more than" test

Aspects evaluated/descriptive measurements	Presence of the notion of "more than"				
Total number of written words	**Yes (n=19)**	**No (n=7)**	**Total (n=26)**	**p value**	**Power[a]**
Mean-median	61.58-64.00	58.71-63.00	60.81-63.00	0.549[b]	0.089
Minimum-maximum	35.00-91.00	42.00-66.00	35.00-91.00		
Standard deviation	11.36	8.24	10.53		
Number of words written incorrectly	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Mean-median	6.16-6.00	15.57-17.00	8.69-6.50	0.037[b]	0.697
Minimum-maximum	0.00-17.00	5.00-28.00	0.00-28.00		
Standard deviation	5.57	9.29	7.82		
Percentage of words written incorrectly	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Mean-median	10.79%-8.20%	26.18%-25.76%	14.94%-11.34%	0.007[b]	0.707
Minimum-maximum	0.00%-34.29%	9.52%-43.75%	0.00%-43.75%		
Standard deviation	10.60%	15.02%	13.55%		
Number of errors	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Mean-median	7.16-6.00	21.14-23.00	10.92-7.50	0.038[b]	0.688
Minimum-maximum	0.00-21.00	7.00-44.00	0.00-44.00		
Standard deviation	7.03	13.95	11.06		
Notion of conservation of quantity	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Yes	19 (100.0%)	6 (85.7%)	25 (96.2%)	0.269[c]	0.285
No	-	1 (14.3%)	1 (3.8%)		
Candies	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Yes	14 (73.7%)	-	14 (53.8%)	0.001[c]	0.998
No	5 (26.3%)	7 (100.0%)	12 (46.2%)		
Reproduction	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Yes	16 (84.2%)	2 (28.6%)	18 (69.2%)	0.014[c]	0.861
No	3 (15.8%)	5 (71.4%)	8 (30.8%)		
Comprehension of essence of story	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Yes	16 (84.2%)	6 (85.7%)	22 (84.6%)	>0.999[c]	0.051
No	3 (15.8%)	1 (14.3%)	4 (15.4%)		
Writing quality	Yes (n=19)	No (n=7)	Total (n=26)	p value	Power[a]
Adequate	19 (100.0%)	1 (14.3%)	20 (76.9%)	<0.001[a]	0.999
Inadequate	-	6 (85.7%)	6 (23.1%)		
Number of correct answers on visual-spatial test	Yes (n=19)	No (n=7)	total (n=26)	p value	Power[a]
Mean-median	5.00-5.00	6.14-7.00	5.31-5.00	0.253[b]	0.232
Minimum-maximum	1.00-8.00	3.00-8.00	1.00-8.00		
Standard deviation	2.19	2.27	2.22		
Time in the visual-spatial test (seconds)	Yes (n=18)	No (n=7)	Total (n=25)	p value	Power[a]
Mean-median	124.17-107.50	104.71-111.00	118.72-109.00	0.262[b]	0.204
Minimum-maximum	62.00-240.00	76.00-130.00	62.00-240.00		
Standard deviation	42.04	22.90	38.24		

[a] Statistical power; [b] Student's *t* test for independent samples; [c] Fisher's exact test.

most frequently broken were C2.16.2, nasalization of the vowel at the end of a syllable and not at the end of a word (23.53%) (for example: *falado* instead of *falando*), C3.10.3 at the end of a word, in decreasing diphthongs, the semivowel /w/ could be codified as "o", "u", or "l" (12.35%) (for example: *pesol* instead of *pensou*),and C2.11 the archiphoneme /R/, at the end of an internal syllable and the end of a word is written with "r" (10.59%) (for example: *grita* for *gritar*). The coefficient of errors per written word obtained was 0.179.

Table 2 shows Pearson and Spearman's coefficient of linear correlation between the number of correct answers on the visual-spatial test, time spent, and aspects of writing.

Table 3 shows the relationship between the performance of the children on the logical thinking test with the notion of "more than" and on the other neuropsychological tests.

In the analysis of the aspects evaluated, it was noted that boys had worse visual-spatial performance, a non-characteristic result. Additionally, they showed a higher percentage of words written incorrectly. In most of the other neuropsychological tests, the boys' performance was similar to that of the girls. Most of the children reproduced the story of three episodes that was told and understood it, making summary inference and reproducing it adequately in writing. The majority of children showed adequate intellectual performance on the logical thinking test, called the intellectual test. Most also demonstrated having the notion of "more than."

DISCUSSION

According to Luria[2], functional unit I regulates the state of consciousness. Unit II, composed by the occipital, temporal and parietal lobes, captures, processes, and integrates (tertiary zones) visual, auditory, and tactile-kinesthetic information. Unit III, with the frontal lobes (tertiary zones), regulates and verifies activity. There are five stages of development: in the first, unit I begins to function, and in the second, primary areas of units II and III start up. In the third, up to 5 years of age, the secondary areas of units II and III begin. In the fourth, from 5 to 8 years of age, the tertiary areas of unit II, and in the fifth, between 10 and 12 years of age, the tertiary areas of unit III activate.

The choice of age group of the study allowed investigation of the neuropsychological performance of individuals whose primary, secondary, and tertiary areas of units II and III were activated, in a typical process of neuromaturation.

From LNNB-C[1], a small set of tests were extracted and have proved especially sensitive for identifying alterations in language or changes in the cognitive aspect.

The ideas and theory of Luria[2,3], on which the battery of tests are based until today, stimulate the interest of different scientists from the whole world who have been able to validate them with the help of modern techniques, such as the performance of motor tasks by individuals during 3T functional magnetic resonance testing, depending on the level of blood oxygen.

The choice of tests proved correct, which is in agreement with a study found in specialized literature[15] in which the authors showed that the LNNB-C battery and the Wechsler Intelligence Scale for Children-Revised (WISC-R) discriminated normal children from those with neurological alterations, besides psychiatric alterations, with similar accuracy.

In order to comment on the evaluation of visual function, it is worth pointing out that in the original proposal[1] of standardization of LNNB-C, performance was classified as normal, intermediate, and altered. In the evaluation of visual function, answering five out of eight equals a score of 1 (one), which is an intermediate performance[1]. The tendency was noted that, the larger the number of correct answers on the visual-spatial test, the smaller the number of words written incorrectly. Thus, linguistic and visual skills are related to orthographic function[16]. This is true for children with typical development. Clinical experience has shown that a deaf non-rehabilitated patient at the right moment can get five or more correct answers on the visual-spatial test, a sign of visual adaptation associated with the right hemisphere[17], but may not have dominated the written code, an attribute of the left hemisphere, which is more phonologically and linguistically orientated. The larger the number of correct answers on the visual-spatial test, the shorter the time to do the said test. The coefficient of errors per written word was similar to that found by judge #1[18] and that obtained in the texts of the 191 children in the 4th grade studied by Zorzi[9]. Therefore, a coefficient smaller than 0.2 errors per word is recommended for students in the 4th grade of public schools. We must point out the importance of an acceptable coefficient of errors per word in a given age bracket, since it may be applied to any written text. The individuals who gave correct answers in the test of "more than" notion also more frequently answered correctly the candy test, reproduction, and also showed satisfactory writing more frequently. They displayed a lower percentage of words written incorrectly and a smaller number of errors. With

these results, it is suggested that the "more than" notion is an indicator of phonological and morphological adequacy, and a predictor of success in reading/writing tasks. The story proved a sensitive instrument for evaluating development: 3rd-grade children reproduced six sentences, according to a study of literature[19], and those of the 4th grade of the sample, reproduced eight. Some children who did not understand the story tried to make an inference for explanation, but instead of using the text heard, based it on their knowledge of the world, a process of memory called "activation"[20]. Difficulty in making a summary inference could be attributed to the distance between the initial information: "he (the crow) painted himself white" and the question: "Why did the other vultures not accept/recognize him?", which would imply a weak connection between the propositions[21]. It agrees with literature[21] as to representation of the text and integration in the connectionist models, but it places more value on the context, the top-down information. The distribution of types of errors was consistent with that of Zorzi[9] for the mean of the first four grades. Breaking the codification rule[10] of nasalizing the vowel at the end of the syllable not at the end of the word may be related to the fact that in Portuguese spoken in Brazil, the nasals "n" and "m" are not pronounced at the end of the syllable, but rather the preceding vowels, with the articulatory act of opening the velum-pharyngealsphincter[22], which is perceptible but not visible. The performance of children on the neuropsychological tests shows that, at 10 years of age, the tertiary areas of units II and III are developed in the majority of children, as had been proposed by Luria[2].

CONCLUSIONS

Ten-year-old students of the population studied understood and reproduced, orally and in writing, a story with three episodes with a low coefficient of errors/written word. The majority responded to the visual-spatial test and showed logical thinking. The absence of the notion of "more than" may be considered a predictor of inadequacy in reading/writing.

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