

Comparison of Neuropsychological Performance between Students from Public and Private Brazilian Schools

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Neuropsychological assessment reveals that certain cognitive changes that take place during the neural development process may be associated with biopsychosocial issues. A substantial body of research has focused on cognitive development in children and adults, but few such studies have been carried out on adolescents. Therefore, research into the processing of neuropsychological functions in adolescents, taking into account the role of major socio-cultural factors such as school type (public vs. private), is highly relevant. The present study sought to assess whether differences in neuropsychological development exist between adolescent students of public (government-funded) and private schools. A total of 373 grade-matched students between the ages of 12 and 18, 190 from public schools and 183 from private schools, took part in the study. All subjects had no self-reported neurologic or psychiatric conditions and sensory disorders. The NEUPSILIN Brazilian Brief Neuropsychological Assessment Battery was administered to this sample. Comparison of mean scores (one-way ANCOVA with socioeconomic score and age as covariates) showed that adolescents attending private schools generally outperformed their public-school peers in tasks involving sustained attention, memory (working and visual), dictated writing, and constructional and reflective abilities. We conclude that school type should be taken into account during standardization of neuropsychological assessment instruments for adolescent and, probably, child populations.

Keywords: neuropsychological assessment, cognition, adolescent, school, socioeconomic status.

La evaluación neuropsicológica evidencia los cambios cognitivos durante el proceso de neurodesarrollo que pueden asociarse a cuestiones biopsicosociales. Existe un número considerable de investigaciones sobre el desarrollo cognitivo en niños y adultos, pero pocos estudios con adolescentes. Por tanto es relevante investigar cómo los adolescentes procesan las funciones neuropsicológicas, considerando el papel de factores socioculturales importantes como el tipo de escuela (pública o privada). El objetivo del presente estudio fue investigar si existen diferencias neuropsicológicas de ejecución entre adolescentes de en escuelas públicas y privadas. Participaron del estudio 373 estudiantes, 190 de escuela pública y 183 de escuela privada, con edades entre 12 y 18 años, emparejados por grado escolar. Ninguno de los sujetos mostraba alteraciones neurológicas, psiquiátricas o sensoriales auto relatadas. Esta muestra fue examinada con el Instrumento Brasileño de Evaluación Neuropsicológica Breve NEUPSILIN. La comparación de medias (ANCOVA unidireccional con puntuación socioeconómica y edad como covariantes) mostró que en general los estudiantes de escuela privada superan a sus pares de escuela pública en atención concentrada, memoria (de trabajo y visual), lenguaje escrito, capacidades constructivas y reflexivas. De esta forma, se concluye que el tipo de escuela debe tenerse en cuenta durante la normalización de instrumentos de evaluación neuropsicológica para adolescentes, y probablemente, población infantil.

Palabras clave: evaluación neuropsicológica, cognición, adolescentes, escuela, nivel socioeconómico.

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The present study is based on the background of developmental neuropsychology, taking into account the relationship between sociodemographic factors and cognitive function processing. In the field of developmental neuropsychology, Brazil has produced an extensive body of literature on aging (Azambuja, 2007; Charchat-Fichman, Caramelli, Sameshima, & Nitrini 2005; Machado, Ribeiro, Leal, & Cotta, 2007; Malloy-Diniz, Lasmar, Gazinelli, Fuentes, & Salgado, 2007) and childhood (Guimarães, Ciasca, & Moura-Ribeiro, 2002; Mello, Miranda, & Muskat, 2005; Salles, Parente, & Freitas, 2010; Santos, 2005). However, few studies have focused on the neuropsychological performance of adults and, particularly, adolescents with no neurological disorder.

Adolescence, which lasts nearly a decade and approximately comprises the period between 12 and 18 years of age (Azambuja, 2007; Bochner, 2006; Inep, 2006; Papalia & Olds, 2000), may be characterized as a period of transition in development, which involves major, highly interconnected biological, cognitive, and psychosocial changes (Blakemore & Choudhury, 2006). With respect to cognitive development, new skills are required in adolescence due to learning-related demands and expectations (Azambuja, 2007), such as development of selective and divided attention, working memory, oral and written language, and executive function (Blakemore & Choudhury, 2006).

In the relationship between cognitive function processing and sociodemographic factors, particular emphasis is due to those of a biological nature, such as age (Rosselli-Cock et al., 2004), and social and environmental factors, such as educational attainment (Foss, Vale, & Speciali, 2005), socioeconomic status (Dotson, Kitner-Triolo, Evans, & Zonderman, 2009; Rosselli-Cock et al., 2004), reading and writing habits and reading proficiency (Coppens, Parente, & Lecours, 1998; Dotson et al., 2009). The usual parameter for assessment of educational attainment is years of formal schooling. However, this variable alone has proven to be insufficient for drawing inferences on reading and writing proficiency and functional literacy, that is, competent use of written language (reading and writing) for social and communicative activities in a variety of cultural contexts (Rojas-Drummond, Albarrán, & Littleton, 2008).

School type is one of the qualitative variables that can be explored in addition to years of schooling. However, a review of the existing literature on these two factors shows a dearth of comparative research on the influence of school type (Rosselli, Matute, & Ardila, 2006; Duncan, 2006; Matute, Sanz, Gumá, Rosselli, & Ardila, 2009; Rosselli-Cock et al., 2004; Nogueira et al., 2005) on neuropsychological development. Most such comparative studies have focused on cognitive-linguistic skills in children (DalVesco, Mattos, Benincá, & Tarasconi, 1998; Leybart, Alégria, Deltour, & Skinkel, 1997; Lins e Silva & Spinillo, 1998; Salles et al., 2010). This concern is apparent in comparative studies on the performance of children attending different school types,

which have been carried out in the U.S. from 1980 (Coleman, Hoffer, & Kilgore, 1982; Wolfle, 1987) to the present time (Avram & Dronkers, 2010), and, more recently, have surfaced in Latin America as well (Cervini, 2003). Neuropsychological assessment studies of adolescents are becoming increasingly frequent in some clinical populations (e.g. Lanfranchi, Jerman, Dal Pont, Alberti, & Vianello, 2010), particularly in association with advanced behavioral techniques such as central auditory processing assessment (Prando, Pawlowski, Fachel, Misorelli, & Fonseca, 2010) and neuroimaging (Rahko et al., 2010). Nevertheless, such studies are still scarce and insufficient when compared with the vast literature on the neuropsychology of children, and older populations.

In Brazil, school type is associated with socioeconomic status, as shown by National Secondary Education Examination (*Exame Nacional do Ensino Médio*, Enem) scores (Ney, Totti, & Reid, 2010). The Enem, an individual, optional standardized test designed to assess the academic skills of a student population representative of several socioeconomic and cultural backgrounds, is offered once yearly to students who are completing or have completed their secondary education. Its main objective is assessment of competencies and skills, with particular emphasis on knowledge building (Inep, 2006). Comparison of Enem scores according to school type reveals a striking contrast in performance between public school students and their private-school peers. Whereas 22.2% of test-takers from private schools obtained scores ranging from good to excellent on the objective portion of the examination, only 1.8% of public school students performed similarly; in the intermediate performance bracket, a similar disparity was found, with 31.1% of participants from public schools obtaining fair to good scores versus 56.9% of current or former students of private schools (Inep, 2006).

The socioeconomic and cultural level of private school attendees tends to be higher than that of public school students (Matute et al., 2009). Ney et al. (2010) stress that, in Brazil, the quality of education is influenced mostly by family income and parental educational achievement; the latter factor was reported by Senler and Sungur (2009) as well. Brazilian public school teachers must be particularly well prepared to deal with substantial diversity in sociocultural backgrounds and baseline knowledge (Carvalho, 2000). Furthermore, the school type factor encompasses several variables in addition to a mere public/private dichotomy, such as quality of teaching, quality of the teacher-pupil learning/teaching interaction (Inep, 2006), environment, type and intensity of teaching, teacher characteristics (Leybaert et al., 1997; Marturano, 1999), and quality of in-school relationships (Gardinal & Marturano, 2007).

Studies on the role of social factors in cognitive processing tend to focus on specific groups of neuropsychological functions. For instance, studies have assessed the influence of educational attainment on executive

function (Ardila, 2005; Plumet, Gil, & Gaonac'h, 2005), attention (Rosselli et al., 2006), memory (Johnson, Storandt, & Balota, 2003), language (Ardilla, Ostrosky-Solis, Rosselli, & Gómez, 2000; Pluchon, Simonnet, Toullat, & Gil, 2002), and constructional praxis (Ostroski-Solis, Ardila, & Rosselli, 1999). Further studies on the role of sociodemographic factors in neuropsychological performance across different cognitive functions are required, as an understanding of this role is essential to understanding the results of any neuropsychological assessment (Andrade, Santos, & Bueno, 2004).

In addition to investigations focusing directly on the effects of school type (Matute et al., 2009), some neuropsychological instruments standardization studies (Malloy-Diniz et al., 2008; Pagliusi & Pasian, 2007) have grouped normative data by school type. This highlights the interest concerning the role of this factor in cognitive performance.

In this context, the present study sought to investigate whether any differences in neuropsychological performance exist between adolescents attending the 7th grade of primary education through the third year of secondary education in public and private schools, controlling for the potential effects of socioeconomic status (SES) and age. The importance of this study is made clear by evidence that cultural variables can interfere with neuropsychological development. It is also justified by the dearth of research on the association between school type and simultaneous processing of more than one cognitive function in adolescents. As Brazilian private school students usually come from more privileged socioeconomic and cultural background than their public school peers and are likely presented with additional exposure to stimuli that boost cognitive development, we hypothesize that their performance will be superior in a variety of neuropsychological tasks. Assessment will take into account cognitive processes involving attention, orientation, perception, memory, arithmetic ability, language, motor ability, and executive functions.

Methods

Participants

The study sample comprised 373 adolescents between the ages of 12 and 18, attending the 7th or 8th grade or the first, second, or third year of secondary education (9th through 11th grades) at public (state-run) and private educational institutions in the Brazilian state of Rio Grande do Sul. Students were allocated into two broad groups, each subdivided by grade: 1) 190 subjects attending public schools (35 seventh-graders, 41 eighth-graders, 39 ninth-graders, 38 tenth-graders, and 37 eleventh-graders); 2) 183 subjects attending private schools (32 seventh-graders, 40 eighth-graders, 37 ninth-graders, 38 tenth-graders, and 36 eleventh-graders).

Students were recruited from a variety of schools across the state of Rio Grande do Sul through direct contact with institutions. Participation was voluntary and required the written informed consent of students, their parents, and their school principals. The study project was approved by the university Research Ethics Committee with approval number 2006530.

The criteria for inclusion were self-reported absence of: 1) current or past alcoholism (maximum daily alcohol intake \leq 24 mL and maximum CAGE Test score of 1 (Ewing, 1984, as administered by Amaral & Malbergier, 2004); 2) use of illicit drugs or benzodiazepines in the 6 months preceding the study; 3) history of neurologic changes (vascular lesions, head trauma, brain tumor, epilepsy, dementia, etc.); 4) uncorrected hearing or visual impairment; and 5) history of inpatient psychiatric care or diagnosis of psychiatric disorders (attention deficit hyperactivity disorder, schizophrenia, etc.). Patients were excluded in case of Yesavage Geriatric Depression Scale scores suggestive of depression ($>$ 19 points) (Ferrari & Dalacorte, 2007; for the applicability of this scale to adolescent subjects, see Strauss, Sherman, & Spreen, 2006).

Sociodemographic variables were measured by means of a questionnaire devised for collection of socio-cultural and health-related data, on the basis of the IBOPE Socioeconomic Survey as administered by the Brazilian Association of Research Companies (Associação Nacional de Empresas de Pesquisa, ANEP). The socioeconomic status score employed was that suggested in Critério de Classificação Econômica Brasil (2008), which is graded on a scale of 34 to 0 points as follows: 30 – 34, class A1; 25 – 29, class A2; 21 – 24, class B1; 17 – 20, class B2; 11 – 16, class C; 6 – 10, class D; 0 – 5, class E. Analysis of reading and writing habits was based on quantification of the frequency of reading (magazines, newspapers, books, etc.) and writing (texts, messages, etc.), scored as follows: 4, daily; 3, several days a week; 2, once weekly; 1, only rarely; 0, never. Reading and writing points were added for an overall score, with 0 – 12 denoting low frequency and \geq 13 denoting high frequency. The questionnaire also included items on gender, age, and medical conditions that could influence test results.

Table 1 (annex) shows the sociodemographic profile of the sample, stratified by school type. Age, educational attainment, number of grade retentions, and socioeconomic score were expressed as means and standard deviations. Regarding gender, 38.2% of public school students were male and 61.8% were female, whereas 42.6% of private school students were male and 57.4% were female. There was no significant association between school type and gender ($p = .408$) or between school type and grade ($\chi^2 = 0.82$; $p = .999$) (both analyzed by means of the chi-square test). Descriptive analysis showed that only 7.7% of students attending public schools belonged to socioeconomic class A, whereas 44% of those attending private schools belonged to this highest of income levels.

Table 1

Sample profile (age, educational attainment, number of grade retentions, socioeconomic score, and reading and writing habits frequency), stratified by school type. All data are expressed as means and standard deviations

Group	Age Mean (SD)	Education Mean (SD)	Grade retention Mean (SD)*	SES score Mean (SD)***	Reading/writing Mean (SD)
Public school	15.39 (1.68)	8.62 (1.42)	.63 (.85)	18.94 (3.74)	15.51 (4.89)
Private school	14.78 (1.60)	8.55 (1.45)	.18 (.61)	23.82 (3.92)	16.15 (4.71)

Note: SES, socioeconomic status; *** $p \leq .001$; * $p \leq .05$.

Comparison between the public and private school groups revealed no statistically significant differences in educational attainment ($F = 0, 032$; $p = .859$) or reading and writing frequency scores ($F = 0, 227$; $p = .634$). Conversely, there were significant between-group differences in age ($F = 6, 326$; $p = .012$), number of grade retentions ($F = 25, 166$; $p \leq .001$), and socioeconomic scores ($F = 1, 533$; $p \leq .001$). On average, private school students were younger, had been held back fewer times, and had higher socioeconomic status scores. It bears noting that the number of grade retentions and age variables are closely related, that is, the public school group was older overall due to the inclusion of a greater number of participants who had been held back for one or more grades. Grade retention reflects a systematic policy of individual schools and of the Brazilian public school system as a whole in addition to actual differences in academic performance. On the basis of these findings, socioeconomic score and age in years were used as covariates for between-group comparison.

Study Procedures and Instrument

Participants were assessed in an adequately lit, well-ventilated, and quiet setting, in a classroom or at home. The NEUPSILIN Brazilian Brief Neuropsychological Assessment Battery (Fonseca, Salles, & Parente, 2008, 2009) was administered to each participant in a single session, with a mean duration of 45 minutes. The NEUPSILIN battery, one of the only neuropsychometric assessment instruments to have been developed and standardized in Brazil, is a brief battery tool that provides a profile of all neuropsychological functions, with norms for subjects between the ages of 12 and 90 and at least one year of formal schooling (Fonseca et al., 2008). It is designed to assess the following functions:

- time and spatial orientation, using time (e.g. day of the week) and space (e.g. site of the interview) subtests, with a maximum score of 8 points;
- sustained attention, using reverse counting and digit sequence repetition subtests, with a maximum score of 27 points;
- visual perception, testing for perception of similarity and mismatch between lines, visual hemineglect (crossing out), face perception (comparison of two portraits), and

face recognition (identification of two drawings of faces among four drawings presented), with a maximum score of 12 points;

- working memory, using the digit ordering test (repetition of 10 sequences of two to six digits, in ascending order) and the reading span task (reading aloud of sentences while simultaneously memorizing the final word of each sentence, with items comprising two to five sentences), with a maximum score of 38 points;

- verbal episodic and semantic memory, using immediate recall (free recall of nine words in three semantic categories), delayed recall (recall of the same nine words after approximately 15 minutes), and word recognition (recognition of the nine words used in the recall subtests out of a list of 18 words), with a maximum score of 36 points;

- semantic memory, using a long-term semantic memory subtest (answering two general knowledge questions), for a maximum score of 5 points;

- visual memory, using a short-term visual memory subtest (picking a semi-complex figure out of a set of three other items), for a maximum score of 3 points;

- prospective memory (spontaneous recall, at the end of the test, of having written a name on a sheet of paper provided at the start of the test), with a maximum score of 2 points;

- arithmetic abilities (four simple math problems, using the pencil-and-paper method), for a maximum score of 8 points;

- oral language, using subtests for naming (naming of two objects and two black-and-white figures), repetition (repetition of eight real words and two non-words), automatized language (automatized counting, naming of the months of the year in order), oral comprehension (identification of an image corresponding to the word or sentence read aloud by the examiner), and inferential processing (explaining the meaning of one proverb and two metaphors), with a maximum score of 22 points;

- written language, with subtests for reading aloud (10 real words and two non-words), reading comprehension (silent reading of words and identification of corresponding images), spontaneous writing (writing a sentence), copied writing (copying a written sentence), and dictated writing (writing down 10 words and two non-words read aloud by the examiner), for a maximum score of 31 points;

Table 2

Performance of public and private school students on NEUPSILIN tasks for which statistically significant differences were detected

Task	Public school	Private school	School type	
	Mean (SD)	Mean (SD)	<i>F</i>	<i>p</i>
Reverse counting	19.31 (2.64)	19.89 (0.841)	6.657	.010
Digit sequence repetition	3.69 (1.91)	4.42 (1.973)	6.353	.012
Reading span	15.45 (4.05)	18.25 (4.40)	22.722	≤ .001
General knowledge (long-term semantic memory)	4.51 (0.57)	4.63 (0.55)	4.342	.038
Figure recognition (short-term visual memory)	2.87 (0.38)	2.93 (0.29)	5.179	.023
Dictated writing	10.97 (1.06)	11.49 (0.73)	9.239	.003
Figure copying (constructional motor ability)	12.44 (1.87)	13.21 (1.765)	7.975	.005
Sequential gesture repetition (reflexive motor ability)	2.47 (0.92)	2.75 (0.67)	4.657	.032

Note: One-way ANCOVA, with socioeconomic status score and age (in years) as covariates.

Table 3

Performance of public and private school students on NEUPSILIN tasks for which no statistically significant differences were detected

Task	Public school	Private school	School type	
	Mean (SD)	Mean (SD)	<i>F</i>	<i>p</i>
Time orientation	3.82 (0.486)	3.85 (0.404)	0.011	0.918
Spatial orientation	3.99 (0.102)	4.00 (0.00)	2.787	0.096
Verification of similarity and mismatch between lines	5.07 (1.044)	5.33 (0.821)	3.203	0.074
Portrait comparison (face perception)	2.55 (0.630)	2.49 (0.733)	0.771	0.380
Face identification (face recognition)	1.94 (0.256)	1.96 (0.205)	0.309	0.578
Ascendant ordering of digits	7.63 (1.518)	8.11 (1.437)	1.713	0.191
Immediate word recall (episodic and semantic memory)	4.99 (1.35)	5.56 (1.38)	2.883	0.09
Delayed word recall (episodic and semantic memory)	3.44 (1.90)	4.12 (1.74)	1.629	0.203
Word recognition (episodic and semantic memory)	13.49 (2.232)	14.21 (2.421)	2.343	0.127
Prospective memory	1.76 (0.519)	1.71 (0.522)	0.872	0.351
Simple math problem solving (arithmetic abilities)	7.36 (1.264)	7.49 (0.943)	0.084	0.772
Word repetition (oral language)	9.96 (0.226)	9.96 (0.219)	0.009	0.925
Automatized counting (automatized oral language)	1.88 (0.327)	1.92 (0.275)	0.003	0.959
Oral comprehension	2.96 (0.189)	2.96 (0.219)	0.244	0.621
Proverb explanation (inference processing)	2.51 (0.598)	2.57 (0.588)	1.030	0.311
Reading aloud (words and non-words)	11.81 (0.481)	11.81 (0.408)	0.029	0.864
Reading comprehension (written language)	2.93 (0.253)	2.96 (0.192)	0.244	0.622
Copied writing	1.95 (0.21)	1.99 (0.07)	2.285	0.131
Spontaneous writing	1.84 (0.41)	1.92 (0.33)	5.107	0.024
Gesture execution (ideomotor abilities)	2.99 (0.102)	3.00 (0.00)	0.107	0.744
Answering questions (problem solving)	1.73 (0.468)	1.81 (0.421)	0.050	0.823
Verbal fluency test (phonemic category)	12.89 (4.161)	13.29 (4.336)	1.182	0.278
Sequential gesture repetition (reflexive motor ability)	2.47 (0.92)	2.75 (0.67)	4.657	.032

Note: Data for the hemineglect and naming (oral language) tasks are not shown as all participants had maximum performance on both, due to the extreme ease of the tasks for subjects with preserved neurologic function.

– praxis, with subtests for ideomotor (carrying out three gestures as requested by the examiner), constructional (e.g. copying a drawing of a cube, clock-drawing test), and reflexive (imitating a sequence of three gestures, in order) abilities, for a maximum score of 22 points;

– executive functions, with subtests for problem solving (answering two verbal questions involving simple problems) and verbal fluency (naming of words from a single phonemic category), for a maximum score of 32 points.

Data analysis

The results of the NEUPSILIN battery were interpreted on the basis of its Scoring Handbook (Fonseca et al., 2009). The mean scores and standard deviations of each group for each subtest were analyzed by means of descriptive and inferential statistics and converted to z-scores. One-way ANCOVA, with socioeconomic status and age (in years) as covariates, was used to detect between-group differences for each subtest of the neuropsychological assessment battery. The significance level was set at $p \leq .05$.

Results

ANCOVA revealed significant differences in NEUPSILIN subtest performance between the public and private school groups, as shown in Table 2 (annex). Private school students significantly outperformed their public school peers on tasks designed to assess attention (digit sequence repetition), working memory (reading span), semantic memory, visual memory (recognition), written language (dictation), and constructional and reflexive abilities.

Table 3 (annex) shows the performance of both groups on NEUPSILIN subtests for which no significant ($p \geq .05$) between-group differences were found.

Discussion

The findings of this investigation showed that adolescents who attend private schools score significantly higher than public school students on tasks designed to examine sustained attention, working memory, written language (dictated writing), and constructional and reflexive praxis. These differences were independent of socioeconomic status or age.

Overall, the hypothesis that private school students would outperform their public school peers in terms of attention, written language, and executive function was confirmed. Statistically significant between-group differences were detected for eight of the 32 subtests of the Brazilian Brief Neuropsychological Assessment Battery.

Based on these findings, one may infer that school type appears to interfere with neuropsychological performance. This result should be interpreted with particular caution,

because, as mentioned in the introduction, the type of school attended is intrinsically associated with a variety of other factors, including quality of teaching methods, quality of the teacher-student interaction (Inep, 2006), learning environment, style and intensity of teaching, teacher characteristics (Leybaert et al., 1997; Marturano, 1999; Senler & Sungur, 2009), quality of in-school relationships (Gardinal & Marturano, 2007), and, in Brazil, the socioeconomic and cultural background of the student population (Ney et al., 2010), although the present study controlled for this variable. Ardila, Rosselli, Matute, and Guajardo (2005) further note that differences between test scores of children attending public and private schools depend on certain extramural conditions, such as parental educational attainment. In the present study, this variable was computed indirectly as part of the socioeconomic status score, but we did not control for it; the impact of this factor warrants further exploration in future studies.

As noted by Demo (2007), the gap between public and private schools in Brazil is considerable, and favors students of the latter. The author based his analysis on 2005 data from the Basic Education Assessment System (*Sistema de Avaliação do Ensino Básico – Saeb-2005*), published by Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep, 2007). According to Demo (2007), private schools are managed from a market-oriented perspective, which imposes consistency; demand good teacher performance and subject teachers to constant assessment; are themselves subject to intense parental pressure; offer superior working conditions; and support their teachers in a variety of ways. Furthermore, teachers in the Brazilian public school system are paid particularly low wages, which can be considered one of the greater disadvantages of public schools in the country.

Neuropsychology has increasingly attempted to become a multidimensional model of reasoning about cognitive and clinical factors that also takes into account the influence of socio-cultural variables on the development of neuropsychological functions. Cultural or transcultural neuropsychology (Andrade & Bueno, 2007) is the field that studies the influence of socio-cultural aspects on cognition—the notion that one's set of formative ideas, competences, and customs modulates one's development and profile of cognitive capacities (Kennepohl, 1999). In the present study, school type was a determinant of differences in performance, even after controlling for socioeconomic status and age.

Data from the Brazilian government's basic education assessment system (SAEB, INEP) show that private school students outperform their public school counterparts in reading and writing tests. According to Dotson, Kitner-Triolo, Evans and Zonderman (2009), reading proficiency is a better predictor of cognitive functioning than years of education, particularly in student populations from disadvantaged socioeconomic backgrounds. In their study of African American and White students of different

socioeconomic levels, the authors found that the association between reading proficiency and neuropsychological performance on verbal and nonverbal cognitive measures held true for African American students regardless of SES. Conversely, among white students, the association varied according to SES, following the above-mentioned profile only in the low-SES group. The authors stress the impact of one's diversity of experiences on cognitive performance.

Ardila (2005) and Malloy-Diniz et al. (2008), using methods similar to those of the present study, found that private school students significantly outperformed their public school peers in mental planning ability, as measured by the Tower of London test. Our study employed other measures of executive functions, verbal fluency, and problem-solving ability, which briefly evaluate other components of executive function—such as inhibition and mental flexibility—rather than planning. Moreover, the small number of test items used in the problem-solving component of the NEUPSILIN battery (two simple verbal problems) and the similarity of performance (both study groups performed well on this task) may have hindered detection of statistically significant differences. Performance on the verbal fluency task, which predominantly measures the executive component of inhibition (Davidson, Gao, Mason, Winocur, & Anderson, 2008), may be more closely related to vocabulary acquisition in formal social contexts than to the quality of the teaching and learning process per se.

Our findings are corroborated by Rosselli, Matute, and Ardila (2006). In their study on reading task performance in public and private school students in the 6-to-7, 8-to-9, 10-to-11, 12-to-13, and 14-to-15-year age groups, age and school type had a significant impact on all reading measures. Performance improved with advancing age, and students attending private schools outperformed their public school counterparts. However, differences were greatest in the youngest groups; in other words, differences became less striking as formal education progressed. These findings suggest that differences may be due to the child's pre-academic surroundings and may be mitigated by prolonged exposure to formal education.

Nogueira et al. (2005), using a flexible battery for neuropsychological assessment of first- and seventh-graders attending public and private schools in urban and suburban settings in Argentina, found significant between-groups differences in tasks designed to evaluate integration, memory, attention, and language. Public school students scored lower than their private school peers. According to the authors, however, comparison of performance revealed no significant differences when the school type variable was analyzed independently of socioeconomic status. These findings are not consistent with those of the present study, where performance differences in sustained attention, working and visual short-term memory, written language, and praxis tasks remained significant even after controlling for socioeconomic level.

Normative studies—such as Pagliusi and Pasian (2007), which sought to develop preliminary norms for the Rey-Osterrieth Complex Figure Test in children between the ages of 9 and 10—have also found differences in performance according to school type, with the advantage held by private school students. The short-term visual memory task of the present study revealed a similar between-group difference. The results of a normative study of the Stroop test (Duncan, 2006) in Brazilian 12-to-14-year-olds also found significant impacts of school type on time to completion. Private school students were able to complete all test tasks more quickly than their public school counterparts.

These performance differences between public and private school students in Brazil and other Latin American countries (Ardila, 2005; Rosselli, et al., 2006; Nogueira et al., 2005) appear to indicate that private schooling plays a clearer role than public schooling in student performance on a variety of neuropsychological functions. Further research efforts are required to determine what underlies the “school type” factor—teacher training, availability of resources to foster learning (Inep, 2006), or characteristics of the families that enroll their children in each school type. These factors could be used to promote the development of students from less favorable socioeconomic and cultural backgrounds. Moreover, children who attend private schools tend to begin their academic lives at an earlier age than public school students (Malloy-Diniz et al., 2008), and are more likely to be encouraged to pursue extracurricular activities (such as art, music, and foreign language studies) that have a direct or indirect impact on cognitive functions development.

As products of the interaction between the environment and the cognitive system, children acquire their basic skill sets, gain knowledge of formal cultures, and internalize the behaviors, standards, reasons, and values of the particular social context to which they are exposed (Korkman, 2001). This set of factors influences acquisition and development of cognitive functions, such as written language, working memory, and episodic memory. In addition to years of education, a parameter that is generally representative of educational attainment and the effects of which have been widely explored in the literature (e.g. Ostroski-Solis et al., 1999), attention must be given to the quality and peculiarities of teaching, as there may be a disconnect between the number of years of formal schooling and the quality of the schooling process itself (Lezak, Howieson, Loring, Hannay, & Fischer, 2004).

Schools are institutions that, above all, provide opportunities for the acquisition of cognitive competencies (Soares, 2007). This should be taken into account by studies designed to standardize neuropsychological assessment instruments for populations at different stages of the life cycle. Psychosocial factors, which may include the family context as well as the school setting, should be investigated. In accordance with the tenets of transcultural neuropsychology, all neuropsychological

assessment instruments, and the interpretation of their findings, should take into account the socioeconomic and cultural diversity of test subjects (Andrade & Bueno, 2007; Matute et al., 2009; Ostrosky-Solis et al., 1999).

Although the findings of this comparative present study provide important evidence for the association between performance on seven neuropsychological functions and school type in a sample of adolescents, some limitations should be taken into account. The first concerns the primary objective of determining whether school type has any impact in two broad groups of adolescents, leaving concomitant determination of the effects of age and/or education as a secondary objective. In this case, we chose to perform analysis of covariance, controlling for age and socioeconomic status. Further studies with larger sample sizes and greater statistical power should investigate both factors simultaneously and even, perhaps, attempt to detect potential interactions.

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