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Inattention Symptoms are Predictors of Neuropsychological Functioning in Children from 3rd and 4th Grades

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ABSTRACT

Symptoms of inattention and hyperactivity/impulsivity, arranged along a continuum, are commonly associated with neuropsychological and academic deficits, even in the general population. The aim of this study is to analyze how Attention Deficit Hyperactivity Disorder (ADHD) symptoms are associated with the performance in neuropsychological and academic abilities (phonological processing, processing speed/automatic attention, executive functions, reading, and spelling) in school-age children. The sample consisted of 216 children from 3rd and 4th grades (M = 8.94 years old, SD =.71) from public elementary schools of two Brazilian capitals. Pearson correlation and Multiple Linear Regression analysis were performed. Inattention symptoms were the only predictors of performance in phonological processing (phoneme suppression and rapid automatized naming of letters), processing speed/automatic attention, executive functions, such as inhibitory control and cognitive flexibility, and reading fluency. Beta values ranged from .14 to .27, and the largest value was related to an inhibitory control task. Inattention, and not hyperactivity/impulsivity symptoms, seems to affect neuropsychological functions even in non-clinical diagnosed children. Contributions and future directions are discussed.

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Introduction

Issues of inattention and hyperactivity/impulsivity (HI) are frequent reasons for referrals to child mental health services. These symptoms are arranged along a continuum, i.e., they are present in each person to varying degrees. However, it is in Attention Deficit Hyperactivity Disorder (ADHD) that these signs are intense and persistent, significantly interfering with people's life. It is estimated that this disorder affects about 5% of the world's population of children and adolescents (Polanczyk, Lima, Horta, Biederman, & Rohde, 2007).

Individuals with ADHD can be characterized as presenting inattention only, HI only, or a combination (American Psychiatric Association [APA], 2013). This dissociation can be explained partially because studies involving twins report correlations (.55 – .62) between inattention and HI, suggesting genetic influences common to both symptoms, but also identifying specific genetic effects for each one. These results partially support distinct etiologies for the two dimensions of ADHD (Greven, Rijsdijk, Asherson, & Plomin, 2011; Kuntsi et al., 2013).

These symptoms, which are correlated but distinct in behavior, are associated with several negative outcomes in childhood that extend into adulthood depending on severity and persistence (APA, 2013). Even when evaluated in the general population and at an early age, inattention and HI predict outcomes in

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physical and mental health as well as academic and social difficulties (Czamara et al., 2013; Holmberg & Bölte, 2014; O'Neill, Rajendran, Mahbubani, & Halperin, 2017). This data is also consistent with the ADHD dimensional model. Although the clinical utility of the categorical definition is well established, there is strong evidence that ADHD is one extreme of a continuous distribution of symptoms of inattention and HI in the population and that etiological factors involved in the disorder also count for the full spectrum of symptoms. For example, neuropsychological deficits may also be present at the subclinical level of the disorder (Coghill & Sonuga-Barke, 2012; Faraone & Larsson, 2018). Thus, a dimensional approach may better elucidate the contribution of each ADHD domain to the neuropsychological and functional impairment, than would a group comparison of ADHD types of presentation (Garner et al., 2013).

Studies that have analyzed the relationships between ADHD symptoms separately and neuropsychological performance have found similar results in both ADHD and clinical population samples. It is suggested that inattention is more strongly associated with children's neuropsychological functions such as processing speed and Executive Functions (EF), which include inhibitory control and cognitive flexibility, when compared to HI symptoms (Goth-Owens, Martinez-Torteya, Martel, & Nigg, 2010; Polner, Aichert, Macare, Costa, & Ettinger, 2014; Rossi et al., 2015; Sørensen, Plessen, & Lundervold, 2011).

In this regard, a study showed that inattention alone predicted deficits in inhibition and cognitive flexibility in children of a community sample (Castagna, Calamia, Roye, Greening, & Davis, 2019). It is suggested that children presenting inattention tend to exhibit a cognitive deficit profile and those presenting HI exhibit a behavioral deficit profile (Channabildas, Pennington, & Willcutt, 2001). In contrast, some studies have been associating both inattention and HI symptoms with executive functioning in children. For example, Miller, Loya, and Hinshaw (2013) found that changes in global EF measures predicted changes in both inattentive and HI symptoms across time in girls with and without ADHD, whereas changes in response inhibition predicted changes in HI symptoms. Besides, Berlin and Bohlin (2002) found a correlation between response inhibition (measured by go/no-go tasks, as well as a Stroop-like task) and hyperactivity in children, and this association did remain significant when controlling for conduct problems. Thus, the relationships between ADHD symptoms and EF in children must be better elucidated.

Regarding academic performance, there are no consistent relationships between HI symptoms and reading, spelling, and math performance, although these symptoms also relate to learning difficulties and social impairment (DuPaul, Morgan, Farkas, Hillemeier, & Maczuga, 2018). Inattention, in turn, is particularly important in predicting children's learning difficulties, such as reading and spelling deficits (Daley & Birchwood, 2010; Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010), although there are fewer studies investigating associations of inattention and HI and spelling outcomes in children.

There is strong evidence that inattention is a correlate of reading-related skills (Allan et al., 2018), as phonological processing. However, studies that have been investigating the associations between phonological processing and ADHD symptoms tend to consider preschool-age children (Sims & Lonigan, 2013; Walcott, Scheemaker, & Bielski, 2010). Therefore, it is still unknown whether inattention symptoms are still relevant to predict phonological processing in older (school-age) children. Considering that the phonological processing (phonological awareness and Rapid Automatized Naming – RAN) may be mediating the association between inattention and difficulty in decoding words, as well as fluency and reading comprehension of school-age children (Martinussen, Grimbos, & Ferrari, 2014; Plourde et al., 2018), we would expect negative associations between inattention and performance in phonological processing even in children in middle elementary school.

In sum, the literature mostly investigates associations between ADHD symptoms and reading words in children. The relation between them is quite clear, especially considering inattention and literacy-related skills. However, the results regarding associations between inattention, HI, and EF are still unclear, as summarized above. Some authors argue that inattention is a strong predictor of EF (Castagna et al., 2019), while others argue that HI stronger predicts EF, especially inhibitory control (Berlin & Bohlin, 2002). Moreover, studies lack in investigating associations between ADHD symptoms and phonological processing in older children (Dittman, 2016) and spelling (Capodieci, Serafini, Dessuki, & Cornoldi, 2018; Re, Mirandola, Esposito, & Capodieci, 2014). Both of these skills are important to academic achievement and impaired in ADHD children. Therefore, given the high occurrence of inattention and HI symptoms during childhood and their impacts on academic performance, research would benefit from a better understanding of the unique effects of these dimensional symptoms on neuropsychological and academic outcomes (Castagna et al., 2019).

Current study

The focus of the present study is to investigate how inattention and HI symptoms are independently associated with a wide range of neuropsychological measures (phonological processing, processing speed/automatic attention, and EF), as well as word reading (regular, irregular, and pseudowords), reading fluency and spelling (words and pseudowords). It also aims to predict the performance of these neuropsychological functions through ADHD symptoms ratings, separately. Symptoms of inattention are expected to be more predictive of performance in neuropsychological and academic abilities than those of HI (Goth-Owens et al., 2010; Pham, 2013; Polner et al., 2014; Sørensen et al., 2011; Walcott et al., 2010).

We believe that the study approach of using multiple measures of phonological processing, processing speed, EF, academic performance, and their associations with different dimensions of ADHD symptoms could further advance the understanding of ADHD consequences in middle elementary school children. Thus, we expect to go overreach literature gaps and contribute to the development of the ADHD dimensional model.

Methods

Participants

The sample consisted of 216 children, 55.1% girls, aged between 8 and 11 years old (M = 8.94, SD = .71). The students were in 3rd (28.7%) and 4th grades (71.3%) of public elementary schools of Porto Alegre (Rio Grande do Sul; 30.5%) and Belo Horizonte (Minas Gerais; 69.5%; Table 1-5). Exclusion criteria were uncorrected auditory or visual difficulties (reported by parents/guardians), intellectual deficit considering scores below the 15th percentile in Raven's Colored Progressive Matrices (CMP – Raven; Angelini, Alves, Custódio, Duarte, & Duarte, 1999), and children who met criteria for both ADHD symptoms and reading disability (comorbidity; n = 6). Reading disability was considered when children performed lower than the 16th percentile of the Aloud Oral single-word and pseudoword reading task (LPI; Salles, Piccolo, & Miná, 2017; Salles, Piccolo, Zamo, & Toazza, 2013), described in the Instruments section below.

Table 1. Demographic data of the sample according to grade (3rd and 4th grades).

	3rd grade	4th grade	*t*	*p*
Age in years M (SD)	8.19 (.47)	9.25 (.55)	−13.19	≤.001***
Sex (Male/Female %)	48.4/51.6	43.5/56.5	.42[I]	.51
City (Belo Horizonte/Porto Alegre %)	64.5/35.5	71.4/28.6	.99[I]	.31
School's IDEB M (SD)	6.57 (.64)	6.69 (.64)	−1.18	.26
Socioeconomic Status M (SD)	27.82 (6.81)	31.50 (7.36)	−3.25	≤.001***
CPM-Raven Percentile (nonverbal reasoning) M (SD)	81.58 (16.79)	81.06 (16.27)	.20	.83
Inattention symptoms score M (SD)	7.44 (5.14)	6.42 (4.59)	1.42	.15
HI symptoms score M (SD)	7.19 (5.23)	6.17 (4.72)	1.39	.16
Combined symptoms score M (SD)	14.63 (9.22)	12.48 (8.08)	1.69	.09

M = mean. SD = Standard Deviation. IDEB = Basic Education Development Index. HI = hyperactivity/impulsivity. I = chi-square. p <.05. p <.01**. p <.001***.*

According to the criteria established by a survey of the Brazilian Association of Research Companies – ABEP (2015), the Socioeconomic Status (SES) distribution of the sample was as follows: A1 (n = 7, 3.5% of the sample); B1 (n = 23; 11.4%); B2 (n = 81; 40.3%); C1 (n = 62; 30.8%); C2 (n = 26; 12.9%); and D-E (n = 2; 1%). Socioeconomic classification “A” corresponds to the highest SES (families with the highest education and income) and “E” the lowest (families with the lowest education and income), considering the Brazilian population statistics from ABEP. This information was not provided by 6.9% of the participants.

Study design and procedures

The present study is cross-sectional, with predictive design. Participants were selected by nonrandom convenience sampling. It was approved by the Research Ethics Committees of the Universities of Belo Horizonte (protocol number 939.562) and Porto Alegre (protocol number 1.023.371). Two evaluation sessions (collective and individual) were held with the children; parents or caregivers signed the Informed Consent Form. The evaluations were conducted only after the children’s written and oral consent.

Parents/caregivers completed the child’s Sociodemographic and Health Conditions Questionnaire, as well as the MTA-SNAP-IV scale (Mattos, Serra-Pinheiro, Rohde, & Pinto, 2006). Children participated in two assessment sessions in a quiet room, inside schools. First, the CPM-Raven (Angelini et al., 1999) and the spelling measures were administered in group sessions involving a maximum of eight students and lasted about 30 minutes. The remaining neuropsychological and reading tests were administered in a second, individual session that lasted approximately 90 minutes. All instruments were administered by trained researchers and did not follow the same order of application for all the individual sessions. At the end of the assessments with the children in each school, reports of each child’s academic performance were prepared for the school and parents/caregivers.

Instruments

Predictors

(a) MTA-SNAP-IV scale (Mattos et al., 2006): Abbreviated version of the Swanson, Nolan, and Pelham Questionnaire (Swanson, 1992; Swanson et al., 2001) which assesses symptoms of inattention, HI, and oppositional defiant behaviors, answered by parents/guardians or teachers. The scale is composed of 26 items corresponding to the list of symptoms for ADHD and Oppositional Defiant Disorder described in the diagnostic criterion A of the DSM-IV, which is virtually the same in the DSM-5. Respondents rated their children’s inattentive (items 1–9), hyperactive-impulsive (items 10–18), and defiant (items 19–26) behaviors using a 4-point Likert scale: 0 (not at all), 1 (just a bit), 2 (pretty much) and 3 (very much). In the present study, this scale was answered by parents or caregivers. The MTA-SNAP-IV scale was translated and adapted for the Brazilian context (Mattos et al., 2006) and it presents psychometric evidence in a sample of Brazilian children (see Costa, Paula, Malloy-Diniz, Romano-Silva, & Miranda, 2018). Moderate to strong correlations were found between the MTA-SNAP-IV Brazilian version and the Brazilian version of the Schedule for Affective Disorders and Schizophrenia for School-Age Children – Present and Lifetime Version (K-SADS-PL). All MTA-SNAP-IV scales had high internal consistency coefficients (all above .91; Costa et al., 2018).

(b) Raven’s Colored Progressive Matrices (CPM-Raven; Angelini et al., 1999): Nonverbal reasoning was assessed using the age-appropriate, Brazilian-validated version of CPM-Raven. In this task, the child must choose between six alternatives which one corresponds to the missing part. The items are presented one by one and organized into three series with increasing difficulties. The first series requires discriminatory precision, while others involve analogies, permutation, and pattern changes, as well as logical relationships (Angelini et al., 1999). This task presented an internal consistency index with Cronbach’s alpha coefficient of .91 in a sample of Brazilian children (Lima et al., 2019).

Outcomes

(a) Phoneme Elision Task (Barbosa-Pereira et al., 2020): Provides a measure of phonemic awareness. The child hears a word pronounced by the examiner and then states which word would result if a specific phoneme was deleted. The test comprises 28 items: in eight of them, the child must delete a vowel, and in the other 20, a consonant. The consonants to be suppressed varied by place and manner of articulation. The phoneme to be suppressed could be in different positions within the words, which ranged from two to three syllables. After the exclusion of the phoneme, the item became another real word. For example: in Portuguese, "atLas" without/l/ gives "atas", "perUa" without/u/gives "pera," etc. Similar examples in English would be "Farm" without/f/giving "arm" and "Cup" without/k/giving "up" (Barbosa-Pereira et al., 2020). A raw number of correct answers was used in the study. The internal consistency of the task was .92 (KR – 20 formula; Lopes-Silva, Moura, Júlio-Costa, Haase, & Wood, 2014).

(a) Digit Span (forward and backward; Figueiredo, 2002): Brazilian version of the Wechsler Intelligence Scale for Children Third Edition (Figueiredo, 2002). Digit Span Forward primarily measures short-term phonological memory while Digit Span Backward measures the child's ability to manipulate verbal information while in temporary storage (working memory). Raw score on each of these measures (accuracy x trials) were used in the present study.

(b) Letter span (forward and backward): This instrument is analogous to the digit span task and measures short-term phonological memory and working memory. The task contains both a forward and a backward letter span condition, each of which is scored on a scale from 2 to 9. It was developed by the authors and it presented internal consistency (Cronbach's alpha) of .66 in a sample of Brazilian children (Lima et al., 2019).

(c) Corsi Block-Tapping Task (forward and backward; Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000; Lima et al., 2020): This task assesses visuospatial short-term and working memory. Total scores were calculated by summing the number of sequences correctly reproduced for forward and backward trials. Raw scores were calculated by summing up the number of sequences reproduced correctly for forward and backward trials. There is evidence of validity in a Brazilian sample of children (Lima et al., 2020).

(d) Phonemic and Semantic Verbal Fluency (Salles et al., 2011; Salles, Sbicigo, Machado, Miranda, & Fonseca, 2014): This task was selected from a Brief Neuropsychological Battery for Brazilian children (NEUPSILIN-INF). In the phonemic fluency section, there are 60 seconds to the child elicit as many words as possible starting with the letter M. In the semantic fluency task, they must name as many animals as possible in 60 seconds. Each section is scored based on the number of correct words elicited in the time provided. There is evidence of the validity and reliability of this task for Brazilian children (Salles et al., 2014).

(e) Five Digit Test (FDT; Sedó, de Paula, & Malloy-Diniz, 2015): A multilingual, Stroop-like instrument to assess EF and attention. The first two parts measure automatic attention and speed processing. Participants are instructed to read Arabic digits varying across 1 to 5 (Reading subtest) and count randomly presented star sets varying across 1 to 5 (Counting subtest). The last two subtests measure controlled attention and executive attention with inhibition and set-shifting tasks. The inhibition task assesses the Stroop effect (Choosing part), the child counts the number of Arabic digits instead of reading the Arabic digit, again varying across 1 to 5. In the set-shifting condition (Switching part), the child counts the number of Arabic digits in most trials, switching to reading the digits when a frame surrounds the stimulus set to a wider board. The measures used in the study were the raw number of errors and response time (RT) measured in milliseconds for each part. This instrument shows evidence of validity and reliability for Brazilian adults (Campos, Silva, Florêncio, & de Paula, 2016).

(f) Contingency Naming Task (CNT; van der Sluis, de Jong, & van der Leij, 2004): This is an experimental task adapted from the regular RAN task. The CNT consists of RAN of letters (D, A, O, S), numbers (1, 2, 3, 4) and figures (square, circle, triangle, and diamond), and it assesses phonological processing (speed of retrieving information from long-term memory). This task also has two measures of EF (inhibitory control and shifting). In the former, children have to name the figure inside another. In the latter, children must switch between naming the figure inside when both figures are black and naming the figure outside when both figures are red. We measured response time (RT) in milliseconds and the raw number of errors for each trial separately (letters, numbers and figures, inhibition, and flexibility). This task presented Cronbach's alpha coefficient of .76 in a sample of Brazilian children (Lima et al., 2019).

(g) Aloud Oral single-word and pseudoword reading task (LPI; Salles et al., 2013, 2017): This task comprises a set of 60 stimuli selected according to regularity, length, frequency, and lexicality. Stimuli are divided equally among three categories (20 regular, 20 irregular, and 20 pseudowords), and matched for frequency and length. The number of correctly read items was used for the analyses. Norms are available for Brazilian children from 6 to 12 years. This instrument presents evidence of the reliability and validity of the Brazilian context (Salles et al., 2013, 2017).

(h) Word Reading Fluency Test (Justi & Roazzi, 2012). The participant has 30 seconds to read 60 regular words. The number of correctly read items in the allotted time is used to calculate a fluency score. We also considered the raw number of errors in this task. The testing included a training session. This task presented Cronbach's alpha of .70 in a sample of Brazilian children (Lima et al., 2019).

(i) Brazilian School Achievement Test (TDE; Oliveira-Ferreira et al., 2012; Stein, 1994). In the present study, only the word spelling (70 words) was considered and the raw number of corrected spelling words was analyzed. The spelling subtest presents evidence of validity for the Brazilian context (Giacomoni, Athayde, Zanon, & Stein, 2015).

(j) Word and Pseudoword Writing Task (Rodrigues, Miná, & Salles, 2017): this task aims to identify the integrity of orthographic routes (phonological, lexical or both) and is composed of 24 words and 24 pseudowords dictation, and it has evidence of validity for the Brazilian context (Rodrigues et al., 2017).

Data analyses

Pearson's correlation analyses were performed by correlating the total scores in the two domains of the MTA-SNAP-IV scale (inattention and HI) with the neuropsychological measures (all tasks described in the Instruments: Outcomes), including age, grade, sex, and nonverbal reasoning.

Multiple Linear Regression analyses were used to verify the prediction of inattention and HI symptoms and other related variables (nonverbal reasoning and age), in the performance of variables that showed significant correlations with ADHD symptoms. The outcomes analyzed in the Regression Models (those that correlated to inattention and/or HI) were: Phoneme Elision Task, Digit Span Backward, Letters RAN (RT), Letters RAN (Errors), FDT – Counting (RT), FDT Counting (Errors), FDT Choosing (RT), FDT Choosing (Errors), FDT Switching (Errors), RAN Figures – Inhibition component (RT), RAN Figures – Inhibition component (Errors), and Reading Fluency (Errors).

We chose not to include the combined symptoms due to the strong correlation between this measure and the symptoms of inattention and HI, resulting in multicollinearity. We opted for the Enter method of variable selection. The analyses were performed using the SPSS 20.0 program and the significance level adopted for all analyses was 5%.

Results

The descriptive results are available in the table below (Table 2), according to each neuropsychological domain and grade.

The Pearson bivariate correlations among all variables are in the tables below.

Neuropsychological variables that showed a significant correlation with ADHD symptoms (Table 3, Table 4, Table 5) were used as outcomes in the regression model. In the models for Digit Span Backward, errors in FDT – Choosing and RT in Figure RAN – Inhibition component,

Table 2. Descriptive results according to each neuropsychological domain and grade (3rd and 4th).

Grade/Variable	3rd grade				4th grade			
Phonological Processing	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
Phoneme Elision	22.15	4.86	8	28	22.27	4.96	4	28
Letter Span Forward	5.31	1.06	2	7	5.49	1.12	3	8
Digit Span Forward	6.45	1.32	2	9	6.81	1.21	4	11
Letters RAN (RT – milisseconds)	23816.07	5373.09	12000	38860	20816.29	4726.16	2398	39110
Letters RAN (Errors)	.13	.42	0	2	.16	.57	0	3
Numbers RAN (RT – milisseconds)	25724.1	6242.11	13700	44460	22481.95	5431.16	12060	48260
Numbers RAN (Errors)	.13	.46	0	3	.16	.57	0	4
Figures RAN (RT – milisseconds)	62171.61	21502.27	66580	116710	52428.39	16326.45	19670	125000
Figures RAN (Errors)	1.39	2.58	0	15	.68	1.5	0	9
Processing Speed/Automatic Attention and Executive Functions	**Mean**	**SD**	**Minimum**	**Maximum**	**Mean**	**SD**	**Minimum**	**Maximum**
Letter Span Backward	5.13	1.12	4	8	5.42	1.18	4	8
Digit Span Backward	3.58	1.02	2	6	3.78	1.31	1	7
Corsi Forward	32.89	12.32	12	63	35.85	11.54	4	63
Corsi Backward	24.32	11.64	0	54	27.97	12.13	2	54
Phonemic Verbal Fluency	6.29	2.62	1	13	8.04	3.08	1	16
Semantic Verbal Fluency	12.37	3.46	4	23	13.53	3.78	1	21
FDT Reading (RT – milliseconds)	32872.9	6258.87	20740	49000	29343.25	5029.53	20310	48430
FDT Reading (Errors)	.06	.24	0	1	.08	.33	0	2
FDT Couting (RT – milliseconds)	46923.45	12713.67	16380	110450	40885.64	8293.10	23080	68780
FDT Couting (Errors)	.60	2.04	0	15	.61	1.34	0	10
FDT Choosing (RT – milliseconds)	77556.58	14125.49	50130	119830	66801.60	13594.70	40340	111940
FDT Choosing (Errors)	3.16	2.77	0	11	2.71	3.5	0	21
FDT Switching (RT – milliseconds)	90111.65	21936.72	12030	150040	74988.43	19704.11	73280	147630
FDT Switching (Errors)	3.94	4.64	0	25	3.25	3.67	0	22
Figures RAN – Inhibition Component (RT – milliseconds)	66717.31	20335.69	33990	130150	55504.57	18563.299	103240	135000
Figures RAN – Inhibiton Component (Errors)	1.13	2.23	0	13	.86	1.74	0	10
Figures RAN – Shifting Component (RT – milliseconds)	106318.16	153015.46	10800	1263000	72279.22	25536.54	80550	180000
Figures RAN – Shifting Component (Errors)	2.54	3.77	0	23	1.96	3.31	0	23
Reading and Spelling Outcomes	**Mean**	**SD**	**Minimum**	**Maximum**	**Mean**	**SD**	**Minimum**	**Maximum**
Regular Word Reading	18.95	.99	15	20	19.21	.88	16	20
Irregular Word Reading	17.40	2.13	11	20	18.47	1.94	10	20
Pseudoword Reading	17.44	1.87	12	20	17.4	2.06	10	20
Reading (Total)	53.79	3.91	42	60	55.09	3.92	40	60
Reading Fluency (Corrects)	25.47	11.14	3	52	36.48	12.42	5	60
Reading Fluency (Errors)	2.79	2.24	0	9	2.08	1.83	0	10
Spelling (Total)	20.48	5.34	6	31	24.64	5.81	4	35
Word Writing	11.79	3.54	5	21	14.56	3.44	3	21
Pseudoword Writing	12.84	3.76	3	21	15.56	3.63	3	22
Writing (Total)	24.56	5.79	11	39	30.07	6.11	6	42

SD = Standard Deviation. RAN = Rapid Automatized Naming. RT = Response Time.

inattention did not contribute significantly. Hyperactivity was not a significant predictor of any variable.

The final regression models indicated that the inattention score contributed most to the errors in the Figure RAN – Inhibition component (*Beta* = .27) which, along with nonverbal reasoning, explains

Table 3. Pearson correlations for phonological processing abilities.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Inattention Symptoms	-	.57***	NS	NS	NS	NS	−.22***	NS	NS	NS	−.17*	.13**	.13**	NS	NS	NS	NS
2. HI Symptoms			NS	NS	NS	NS	NS	NS	NS	NS	.15*	NS	NS	NS	NS	NS	NS
3. Grade				.67***	NS	.26***	NS	NS	NS	NS	NS	−.26***	−.26***	NS	NS	−.24***	−.17*
4. Age					NS	.19**	NS	NS	NS	NS	NS	−.19***	20**	NS	NS	−.17**	−.14*
5. Sex						NS	NS	NS	NS	−.18*	NS	NS	NS	NS	NS	.17*	NS
6. Nonverbal reasoning							.32***	NS	NS	.17*	.26***	NS	NS	NS	NS	−.20**	−.17*
7. Phoneme Elision								.32***	.24***	.21**	.35***	−.15**	−.23***	−.16*	−.15*	−.17**	−.18**
8. Letter Span Forward									.23***	.30***	.29***	NS	NS	NS	NS	−.17**	−.17*
9. Letter Span Backward										.18*	.22**	NS	NS	NS	NS	NS	NS
10. Digit Span Forward											.22***	NS	NS	NS	NS	NS	NS
11. Digit Span Backward												NS	−.23***	NS	−.23**	−.19**	−.23**
12. Letters RAN (RT – milliseconds)													.26***	.33***	NS	.15**	NS
13. Letters RAN (Errors)														.21***	.63***	.26***	.43***
14. Numbers RAN (RT – milliseconds)															.28***	.16*	NS
15. Numbers RAN (Errors)																.19***	.46***
16. Figures RAN (RT – milliseconds)																	.38***
17. Figures RAN (Errors)																	-

HI = Hyperactivity/impulsivity. RT = Response Time. RAN = Rapid Automatized Naming. NS = not significant. *$p \leq .05$; **$p \leq .01$; *** $p \leq .001$

Table 4. Pearson correlations for processing speed/automatic attention and EF.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
1. Inattention Symptoms	-	.57***	NS	NS	NS	NS	NS	NS	NS	NS	.17*	.19*	.18**	.17***	NS	.24***	.13*	.28***	NS	NS
2. HI Symptoms			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	.16*	NS	NS	NS	NS	NS	NS
3. Grade				.67***	NS	.26***	NS	NS	−.28**	NS	−.27**	NS	−.33***	NS	−.32**	NS	−.25**	NS	−.18*	NS
4. Age					NS	.19**	NS	NS	−.22**	NS	−.25***	NS	−.22**	NS	−.33***	NS	−.21**	NS	−.16*	NS
5. Sex						NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	.14*	NS	NS	NS
6. Nonverbal reasoning							.30***	.37**	NS	NS	−.23**	NS	−.27***	NS	−.20**	−.24**	−.26***	−.17***	NS	−.18**
7. Corsi Forward								.30***	NS	NS	NS	NS	−.30***	NS	−.32***	NS	−.17*	NS	NS	NS
8. Corsi Backward									NS	NS	NS	−.25**	−.18**	−.18**	−.17**	−.16**	−.25**	NS	NS	−.16*
9. FDT – Reading (RT – milliseconds)										NS	.58***	.21**	.51***	NS	.39***	.16*	.45***	.20***	.21***	.16*
10. FDT – Reading (Errors)											NS	NS	NS	NS	NS	NS	NS	NS	.19*	NS
11. FDT – Counting (RT – milliseconds)												.54***	.57***	NS	.47***	.18**	.55***	.34***	.27***	.29***
12. FDT – Counting (Errors)													NS	.16*	NS	.28***	.30***	.54***	.15*	.40***
13. FDT – Choosing (RT – milliseconds)														.22**	.64***	.17*	.52***	NS	.24***	NS
14. FDT – Choosing (Errors)															NS	.54***	NS	NS	NS	.14*
15. FDT – Switching (RT – milliseconds)																NS	.45***	NS	NS	NS
16. FDT – Switching (Errors)																	.31***	.29***	NS	.18**
17. RAN Figures – Inhibition component (RT – milliseconds)																		.40***	.28***	.28***
18. RAN Figures – Inhibition component (Errors)																			NS	.28***
19. RAN Figures – Shifting component (RT – milliseconds)																				.52***
20. RAN Figures – Shifting component (Errors)																				-

*FDT = Five Digit Test. RT = Response Time. RAN = Rapid Automatized Naming. NS = not significant. *p ≤.05; ** p ≤.01; *** p ≤.001*

Table 5. Pearson correlations for reading and spelling outcomes.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Inattention Symptoms	-	.57***	NS	NS	NS	NS	NS	NS	NS	NS	NS	.20**	NS	NS	NS	NS
HI Symptoms			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Grade				.67***	NS	.26***	NS	.23***	NS	.15*	.20**	NS	.31***	.36***	.33***	.41***
Age					NS	.19**	NS	.23**	NS	.15*	.20**	NS	.30***	.29***	.34***	.37***
Sex						NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nonverbal reasoning							.23***	.27***	NS	.21**	.22**	−.27***	.34***	.26***	.19*	.27***
Regular Word Reading								.51***	.36***	.21***	.22***	−.27***	.34***	.26***	.25**	.43***
Irregular Word Reading									.39***	.84***	.54***	−.35***	.64***	.58***	.40**	.575***
Pseudoword Reading										.80***	.36***	−.34***	0.4***	.33***	.33***	.38***
Reading Total											.57***	−.44***	.65***	.58***	.43***	.60***
Reading Fluency (corrects)												−.43***	.60***	.73***	.36***	.65***
Reading Fluency (errors)													−.52***	−.38***	−.36***	−.42***
Spelling														.68***	.59***	.74***
Word Writing															.46***	.84***
Pseudoword Writing																.86***
Writing Total																-

*HI = hyperactivity/impulsivity. NS = not significant. *p ≤.05; ** p ≤.01; *** p ≤.001*

9% of task performance. Inattention also contributed to the increase in FDT Switching – errors (*Beta* = .21) which, along with nonverbal reasoning, explains 9% of performance in this task. Inattention symptoms also contributed to the increase in FDT Counting – errors (*Beta* = .19), explaining 3% of total performance. Although other variables may be involved in explaining outcomes, inattention symptoms interfere with the performance of tasks that involve EF components such as cognitive flexibility, inhibitory control, and also processing speed, when evaluating errors in these tasks (Table 4). For the variables that measured RT, the contributions of inattention symptoms were low; or, as in the case of Figure RAN – Inhibition component, inattention symptoms were not significant predictors in the model (Table 6).

In addition to these EF measures, symptoms of inattention in addition to nonverbal reasoning also predicted the performance in the phoneme elision task (*Beta* = −.18), explaining 13% of the total task, and contributed to more errors in the reading fluency task (*Beta* = .16) which, in addition to nonverbal reasoning, explained 9.7% of the total task.

Table 6. Multiple linear regressions of each neuropsychological function.

Variables	Beta	Partial t	*p*
Phoneme Suppression (R^2 =.14; R^2adj =.13; *p* ≤.001*)**			
Nonverbal reasoning	.30	4.76	≤.001***
Inattention	.18	-2.85	.005
Digit Span Backward (R =.10; R^2adj =.08; *p* ≤.001*)**			
Nonverbal reasoning	.26	3.55	≤.001***
Inattention	-.08	-1.00	.31
Hyperactivity	-.12	-1.43	.15
Letters RAN (RT) (R =.06; R^2adj =.05; *p* =.002)**			
Age	-.20	-3.01	.003**
Inattention	.14	2.13	.03*
Letters RAN (Errors) (R =.02; R^2adj =.01; *p* =.12)			
Age	.03	.49	.62
Inattention	.13	1.98	.05*
FDT Counting (RT) (R =.12; R^2adj =.11; *p* ≤.001*)**			
Nonverbal reasoning	-.17	-2.57	≤.001***
Age	-.22	-3.42	≤.001***
Inattention	.15	2.4	.01*
FDT Counting (Errors) (R =.04; R^2adj =.03; *p* =.004)**			
Inattention	.19	2.89	.004**
FDT Choosing (RT) (R =.13; R^2adj =.11; *p* ≤.001*)**			
Nonverbal reasoning	-.21	-3.21	.002**
Age	-.19	-2.88	.004**
Inattention	.16	2.45	.01*
FDT Choosing (Errors) (R =.04; R^2adj =.03; *p* =.01*)			
Inattention	.10	1.22	.22
Hyperactivity	.12	1.54	.12
FDT Switching (Errors) (R =.10; R^2adj =.09; *p* ≤.001*)**			
Nonverbal reasoning	-.21	-3.28	≤.001***
Inattention	.21	3.25	≤.001***
RAN Figures – Inhibition Component (RT) (R =.10; R^2adj =.09; *p* ≤.001*)**			
Nonverbal reasoning	-.21	-3.16	.002**
Age	-.17	-2.61	.01*
Inattention	.11	1.72	.08
RAN Figures – Inhibition Component (Errors) (R =.10; R^2adj =.09; *p* ≤.001*)**			
Nonverbal reasoning	-.13	-2.08	.04*
Inattention	.27	4.10	≤.001***
Reading Fluency (Errors) (R =.10; R^2adj =.09; *p* ≤.001*)**			
Nonverbal reasoning	-.23	- 3.81	≤.001***
Inattention	.16	2.63	.01*

*HI = Hyperactivity/Impulsivity. RAN = Rapid Automatized Naming. RT = Response Time. FDT = Five Digit Test. *p ≤.05. **p ≤.01. ***p ≤.001.*

Discussion

The present study aimed to investigate how inattention and HI symptoms, separately, are associated with and are predictive of a wide range of neuropsychological skills, including reading and spelling performance. Corroborating our main hyphotesis, inattention symptoms reported by children's parents were more important in predicting performance in the neuropsychological tasks of phonological processing (phoneme suppression and RAN of letters), processing speed/automatic attention, EF, such as inhibitory control and cognitive flexibility, and reading fluency. In comparison, HI symptoms were not significant predictors of any variable. This result corroborates studies that show inattention is more strongly associated with poorer performance in these functions than are the symptoms of HI (Goth-Owens et al., 2010; Pham, 2013; Polner et al., 2014; Sørensen et al., 2011; Walcott et al., 2010).

In the present study, among the skills most strongly predicted by inattention was a measure of phonological awareness. Explanations for these associations are not yet fully established in the literature. This relationship may be mainly a result of common genetic influences for inattention and phonological processing. On the other hand, early attention difficulties may interfere with the learning of certain emergent skills, such as those related to phonological awareness and vocabulary (Sims & Lonigan, 2013; Walcott et al., 2010). Thus, it is supposed that early attentional deficits may negatively impact school-age reading outcomes by compromising the development of language skills, which in turn impairs later reading achievement (O'Neill, Thornton, Marks, Rajendran, & Halperin, 2016).

In fact, in one study, the relationship between inattention and beginning word identification in children was mediated by pre-reading skills, suggesting that attention problems may compromise reading development during the earliest stages of learning to read through their impact on pre-reading skills, as phonological processing (Dittman, 2016). Our study adds the association between inattention and phonological awareness is yet significant in older children. It seems that inattention still plays an important role in literacy even after the primary school years.

Furthermore, it is noteworthy that the task of Phoneme Elision involves the active manipulation of information in working memory and attentional difficulties can compromise cognitive processing in this context. There is evidence that inattention significantly predicts performance in verbal working memory tasks (Elisa, Balaguer-Ballester, & Parris, 2016; Rogers, Hwang, Toplak, Weiss, & Tannock, 2011). However, our study did not demonstrate significant associations between them. This can be explained partially because the tasks that assessed working memory (Digit and Letter Span and Corsi Blocks) had low-performance variability possibly interfering with the correlation/ regression analysis. Thus, the Phoneme Elision may have been a more sensitive measure of working memory in this sample of children.

Inattention also explained part of the performance in children's processing speed/automatic attention, as suggested in the literature (Thorsen, Meza, Hinshaw, & Lundervold, 2018). Processing speed is the cognitive ability of process information and to generate appropriate timed responses (Weiler, Bernstein, Bellinger, & Waber, 2000). Inattentive children are particularly vulnerable to impairment in this ability (Rossi et al., 2015). We also found an association between inattention and other EF tasks. According to the established hypothesis, inattention symptoms contributed to a greater number of errors in tasks that require cognitive flexibility. The relationship between symptoms of inattention in school-age children and cognitive flexibility has already been verified by both a standardized instrument and an ecological EF measurement (Sørensen et al., 2011).

An interesting result of this study is how inattention rather than hyperactivity predicted inhibition scores. Among all variables, the symptoms of inattention contributed more to errors in Figure RAN – Inhibition component. In this task, specifically, longer response time was needed compared to naming geometrical figures only and requiring stimulus inhibition, thus also evaluating interference control, similar to the Stroop effect (van der Sluis et al., 2004). Interference control is a component of the inhibitory control system (Diamond, 2013) in which children with ADHD commonly have an impairment (Lansbergen, Kenemans, & van Engeland, 2007).

This result contrasts with some previous studies showing that hyperactivity is the ADHD component associated with inhibition difficulties (Berlin & Bohlin, 2002). This could be partially explained because performance on the Stroop-like tests (verbal inhibitory control – CNT and FDT tasks, for example) tends to be specifically associated with inattention, while tasks requiring motor response (e.g. go/no go tasks) were associated with HI (Polner et al., 2014). It is important to note, for example, that studies using Stroop Color-Word Test found correlations with FDT performance (De Paula, Abrantes, Neves, & Malloy-Diniz, 2014; De Paula et al., 2011). Interestingly, a study aimed at parsing ADHD-related heterogeneity in its underlying neurobiology by investigating functional connectivity across multiple brain networks found that clusters within the visual networks were primarily related to inattention and reaction time variability. Visual areas are involved in maintaining or suppressing spatial attention to irrelevant stimuli, a demand for interference control tasks. While findings within the sensorimotor networks are mainly linked to HI and both reward sensitivity and working memory (Pruim et al., 2019).

Besides, we highlight that an interesting result of the present study is that inattention symptoms are stronger predictors of errors in EF performance (in shifting and inhibition tasks of FDT and CNT components) than of RT in these tasks. In this sense, we can consider that children with ADHD symptoms in our sample tended to present impairments in the optimization of the speed-accuracy tradeoff (Mulder et al., 2010). It is possible that the children preferred to maintain adequate RT, despite the greater risk of committing errors.

It is also important to consider that the inattention dimension assessed by the MTA-SNAP-IV scale (based on Diagnostic and Statistical Manual of Mental Disorders – DSM criteria) is closely associated with measuring the children's inhibition difficulties and their functional consequences (e.g., "distracted by external stimuli", "can't pay close attention to details or makes careless mistakes in schoolwork or assignments"). This also partly explains the greater association of symptoms of inattention measured by this Questionnaire with EF and, especially, inhibitory control measures (Channabildas et al., 2001).

Inattention also predicted the amount of reading fluency errors in the present study. The association between inattention and reading fluency was previously identified. Inhibiting behaviors, whose deficits may be present in children with ADHD symptoms (Koltermann et al., 2020), allow individuals to process visual and auditory information while preventing them from reacting to stimuli quickly. This aspect is particularly important for reading fluency while some children may impulsively read a word incorrectly, thus causing a greater number of errors than expected. Thus, reading fluency would demand processing at an attentional level. Therefore, inattentive symptoms can influence reading skills at this level (Pham, 2013).

Contrary to expectations, symptoms of inattention did not correlate with word/pseudoword identification reading measures and spelling performance. These can be explained, partially, because of the measures used here. The word/pseudoword identification reading measures is a task that assesses children from 6 to 12 years old and tends to present ceiling effects in children from 10 years old. Since we excluded the children with reading difficulties, the performance variability could be small. Besides, the inattention scores (on average) were quite low in our sample, which can help to partially explain the lack of associations with reading scores. The same explanations could be addressed to the lack of effects on the spelling task.

Conclusions

The present study has important contributions. First, by using a dimensional approach to ADHD symptoms, we were able to indicate how and to what extent these symptoms are individually associated with children's performance in a wide range of neuropsychological and academic skills for assessment purposes. In this sense, the results presented here add the literature by showing that inattention symptoms are relevant in predicting 1) phonological processing, 2) inhibitory control, 3) errors more than RT in processing speed/automatic attention and EF tasks, and 4) errors, not correct words read, in a reading fluency task. Second, our sample was represented by middle elementary school-age children and, even for those older children, inattention predicted phonological processing measures. Third, the results suggest the hypothesis that phonological processing, processing speed, and EF are protective factors of the impact of inattention symptoms on school performance of third and fourth grades children since those neuropsychological skills predict different outcomes in children, such as the learning of reading/spelling and overall academic success. Finally, our results have practical relevance, in both clinical and educational contexts, in suggesting that rates of inattention, even at less severe levels, are risk factors that contribute to poor neuropsychological performance and are associated with impairments to healthy lifelong development (Holmberg & Bölte, 2014; O'Neill et al., 2017; Thorsen et al., 2018).

Limitations and future directions

It is important to consider some limitations. First, the ADHD symptoms were assessed only by parents/guardians, limiting the child's behavior to their own opinion and to the family context. Therefore, teachers' evaluations of symptoms could also be useful in considering the presence of signs of inattention and HI, also in the children's routines at school, where the demands for attentional control and other EF are higher. Second, correlations of these parent-reported HI measures with direct measures of motor activity are typically modest, possibly reflecting respondent bias. Objective methods that clarify the relationship between HI and neuropsychological performance in children (Sarver, Rapport, Kofler, Raiker, & Friedman, 2015) would be an important improvement for future studies. Third, the lesser impairment of neuropsychological performance associated with HI symptoms can also be explained by the fact that hyperactive children find a new situation in the testing context: it is a structured, stimulating environment, associated with rewards and, thus, provides motivation to do well, however, we did not measure children motivation to assessment. Fourth, the limitations of the MTA-SNAP-IV scale (Mattos et al., 2006) for evaluating ADHD symptoms are also highlighted. Validity studies already conducted have furnished neither the accuracy of this scale for ADHD screening in a nonclinical sample nor control for other mental health characteristics (Costa et al., 2018). In general, there are few studies that investigate the psychometric properties of this instrument in the Brazilian context.

ADHD symptoms in school-age children are complex phenomena, even though with well-established effects on different children outcomes. The dimensional approach, investigated here, might help to distinguish different impacts of inattention and HI symptoms. Future studies could also assess prediction of ADHD symptoms with "hot" EF (e.g. go/no go tasks, delayed gratification), with mathematical skills and ecological measures of EF, refining the understanding of the relationship between inattention, HI, and neuropsychological functions. We also suggest exploring neuropsychological abilities and environmental measures (e.g. SES and parenting practices) as mediators/moderators of the relationship between symptoms of inattention and HI and outcomes in the child's life, such as academic performance.

Disclosure

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References

ABEP, Associação Brasileira das Empresas de Pesquisa. (2015). Critério Brasil. Retirado de: http://www.abep.org/criterio-brasil

Allan, D. M., Allan, N. P., Lonigan, C. J., Hume, L. E., Farrington, A. L., & Vinco, M. H. (2018). The influences of multiple informants' ratings of inattention on preschoolers' emergent literacy skills growth. *Learning and Individual Differences*, *65*, 90–99. doi:10.1016/j.lindif.2018.05.014

American Psychiatric Association. (2013). DSM-5 Manual Diagnóstico e Estatístico de Transtornos Mentais. (5ª edição). Porto Alegre: Editora Artmed.

Angelini, A., Alves, I., Custódio, E., Duarte, W., & Duarte, J. (1999). *Manual Matrizes Progressivas Coloridas de Raven: Escala especial*. São Paulo, Brasil: Centro Editor de Testes e Pesquisas em Psicologia.

Barbosa-Pereira, D., Martins, P. S. R., Guimarães, A. P. L., Silva, E. D. O., Batista, L. T., Haase, V. G., & Lopes-Silva, J. B. (2020). How good is the phoneme elision test in assessing reading, spelling and arithmetic-related abilities? *Archives of Clinical Neuropsychology*, 1–16. doi:10.1093/arclin/acz085

Berlin, L., & Bohlin, G. (2002). Response inhibition, hyperactivity, and conduct problems among preschool children. *Journal of Clinical Child & Adolescent Psychology*, *31*(2), 242–251. doi:10.1207/s15374424jccp3102_09

Campos, M. C., Silva, M. L., Florêncio, N. C., & de Paula, J. J. (2016). Confiabilidade do Teste dos Cinco Dígitos em adultos brasileiros. *Jornal Brasileiro De Psiquiatria*, *65*(2), 135–139. doi:10.1590/0047-2085000000114

Capodieci, A., Serafini, A., Dessuki, A., & Cornoldi, C. (2018). Writing abilities and the role of working memory in children with symptoms of attention deficit and hyperactivity disorder. *Child Neuropsychology*, 1–19. doi:10.1080/09297049.2018.1441390

Castagna, P. J., Calamia, M., Roye, S., Greening, S. G., & Davis, T. E. (2019). The effects of childhood inattention and anxiety on executive functioning: Inhibition, updating, and shifting. *ADHD Attention Deficit and Hyperactivity Disorders*, *11*(4), 423–432. doi:10.1007/s12402-019-00306-7

Channabildas, N., Pennington, B. F., & Willcutt, E. G. (2001). A comparison of the neuropsychological profiles of the DSM-IV subtypes of ADHD. *Journal of Abnormal Child Psychology*, *29*(6), 529–540. doi:10.1023/a:1012281226028

Coghill, D., & Sonuga-Barke, E. J. (2012). Annual research review: Categories versus dimensions in the classification and conceptualisation of child and adolescent mental disorders – Implications of recent empirical study. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *53*(5), 469–489. doi:10.1111/j.1469-7610.2011.02511.x

Costa, D. S., Paula, J. J., de Malloy-diniz, L. F., Romano-Silva, M. A., & Miranda, D. M. (2018). Parent SNAP-IV rating of attention-deficit/hyperactivity disorder: Accuracy in a clinical sample of ADHD, validity, and reliability in a Brazilian sample. *Jornal De Pediatria*. doi:10.1016/j.jped.2018.06.014

Czamara, D., Tiesler, C. M. T., Kohlböck, G., Berdel, D., Hoffmann, B., Bauer, C.-P., ... Heinrich, J. (2013). Children with ADHD symptoms have a higher risk for reading, spelling and math difficulties in the GINIplus and LISAplus cohort studies. *PLoS ONE*, *8*(5), e63859. doi:10.1371/journal.pone.0063859

Daley, D., & Birchwood, J. (2010). ADHD and academic performance: Why does ADHD impact on academic performance and what can be done to support ADHD children in the classroom? *Child: Care, Health and Development*, *36*(4), 455–464. doi:10.1111/j.1365-2214.2009.01046.x

De Paula, J. J., Abrantes, S., Neves, F., & Malloy-Diniz, L. F. (2014). The five digits test on the assessment of psychiatric patients with heterogeneous educational backgrounds: Evidences of validity on the assessment of bipolar disorder. *Clinical Neuropsychiatry*, *11*(3), 103–107. Retrieved from https://www.semanticscholar.org/paper/THE-FIVE-DIGITS-TEST-ON-THE-ASSESSMENT-OF-PATIENTS-Paula-Abrantes/56948165b06468c42c363d9c72a13706216d290b

De Paula, J. J., Ávila, R., Souza, D. S., Moraes, E. N., Bicalho, N., Correa, H., ... Malloy-Diniz, L. (2011). Assessing processing speed and executive functions in low educated older adults: The use of the five digit test in patients with Alzheimer's disease, mild cognitive impairment and major depressive disorder. *Clinical Neuropsychiatry*, *8*(6), 339–346. Retrieved from https://www.clinicalneuropsychiatry.org/clinical-neuropsychiatry-volume-8-issue-6-december-2011/

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology*, *64*(1), 135–168. doi:10.1146/annurev-psych-113011-143750

Dittman, C. K. (2016). Associations between inattention, hyperactivity and pre-reading skills before and after formal reading instruction begins. *Reading and Writing*, *29*(9), 1771–1791. doi:10.1007/s11145-016-9652-x

DuPaul, G. J., Morgan, P., Farkas, G., Hillemeier, M., & Maczuga, S. (2018). Eight-year latent class trajectories of academic and social functioning in children with attention-deficit/hyperactivity disorder. *Journal Of Abnormal Child Psychology*, 1–14. doi:10.1007/s10802-017-0344-z

Elisa, R. N., Balaguer-Ballester, E., & Parris, B. A. (2016). Inattention, working memory, and goal neglect in a community sample. *Frontiers in Psychology*, *7*. doi:10.3389/fpsyg.2016.01428

Faraone, S. V., & Larsson, H. (2018). Genetics of attention deficit hyperactivity disorder. *Molecular Psychiatry*. doi:10.1038/s41380-018-0070-0

Figueiredo, V. L. M. (2002). *WISC-III: Escala de Inteligência Wechsler para Crianças. Manual Adaptação e Padronização Brasileira*. São Paulo, Brazil: Casa do Psicólogo.

Garner, A. A., O'Connor, B. C., Narad, M. E., Tamm, L., Simon, J., & Epstein, J. N. (2013). The relationship between ADHD symptom dimensions, clinical correlates, and functional impairments. *Journal of Developmental & Behavioral Pediatrics*, *34*(7), 469–477. doi:10.1097/dbp.0b013e3182a39890

Giacomoni, C. H., Athayde, M. L., Zanon, C., & Stein, L. M. (2015). Teste do Desempenho Escolar: Evidências de validade do subteste de escrita. *Psico-USF*, *20*(1), 133–140. doi:10.1590/1413-82712015200112

Goth-Owens, T. L., Martinez-Torteya, C., Martel, M. M., & Nigg, J. T. (2010). Processing speed weakness in children and adolescents with non-hyperactive but inattentive ADHD (ADD). *Child Neuropsychology*, *16*(6), 577–591. doi:10.1080/09297049.2010.485126ARNETT2012

Greven, C., Rijsdijk, F., Asherson, P., & Plomin, R. (2011). A longitudinal twin study on the association between ADHD symptoms and reading. *Journal Of Child Psychology And Psychiatry*, *53*(3), 234–242. doi:10.1111/j.1469-7610.2011.02445.x

Holmberg, K., & Bölte, S. (2014). Do symptoms of ADHD at ages 7 and 10 predict academic outcome at age 16 in the general population? *Journal of Attention Disorders*, *18*(8), 635–645. doi:10.1177/1087054712452136

Justi, C., & Roazzi, A. (2012). A contribuição de variáveis cognitivas para a leitura e a escrita no Português Brasileiro. *Psicologia: Reflexão E Crítica*, *25*(3), 605–614. doi:10.1590/S0102-79722012000300021

Kessels, R. P. C., van Zandvoort, M. J. E., Postma, A., Kappelle, L. J., & de Haan, E. H. F. (2000). The corsi block-tapping task: Standardization and normative data. *Applied Neuropsychology*, *7*(4), 252–258. doi:10.1207/S15324826AN0704_8

Koltermann, G., Becker, N., Lopes-Silva, J. B., Gomides, M. R. A., Paiva, G. M., Haase, V. G., & Salles, J. F. (2020). Are cool executive functions more salient in ADHD symptoms than in reading disability? *Dementia & Neuropsychologia*, *14*(1), 47–55. doi:10.1590/1980-57642020dn14-010008

Kuntsi, J., Pinto, R., Price, T. S., van der Meere, J. J., Frazier-Wood, A. C., & Asherson, P. (2013). The separation of ADHD inattention and hyperactivity-impulsivity symptoms: Pathways from genetic effects to cognitive impairments and symptoms. *Journal of Abnormal Child Psychology*, *42*(1), 127–136. doi:10.1007/s10802-013-9771-7

Lansbergen, M. M., Kenemans, J. L., & van Engeland, H. (2007). Stroop interference and attention-deficit/hyperactivity disorder: A review and meta-analysis. *Neuropsychology*, *21*(2), 251–262. doi:10.1037/0894-4105.21.2.251

Lima, C. S., Souza Marques, B., Ferreira Carvalho, C., Siquara, G. M., Bezerra, M. L. O., Duarte, T. S., … Abreu, N. (2020). Visuospatial working memory: A socioeconomic normative reference of the corsi block-tapping task for children aged 7 to 12 years old in Brazil. *Psychology & Neuroscience*. Advance online publication. doi:10.1037/pne0000205

Lima, M., Piccolo, L. R., Basso, F. P., Júlio-Costa, A., Lopes-Silva, J. B., Haase, V. G., & Salles, J. F. (2019). Neuropsychological and environmental predictors or reading performance in Brazilian children. *Applied Neuropsychology: Child*, 1–11. doi:10.1080/21622965.2019.1575737

Lopes-Silva, J. B., Moura, R., Júlio-Costa, A., Haase, V. G., & Wood, G. (2014). Phonemic awareness as a pathway to number transcoding. *Frontiers in Psychology*, 5. doi:10.3389/fpsyg.2014.00013

Martinussen, R., Grimbos, T., & Ferrari, J. L. S. (2014). Word-level reading achievement and behavioral inattention: Exploring their overlap and relations with naming speed and phonemic awareness in a community sample of children. *Archives of Clinical Neuropsychology*, *29*(7), 680–690. doi:10.1093/arclin/acu040

Mattos, P., Serra-Pinheiro, M. A., Rohde, L. A., & Pinto, D. (2006). Apresentação de uma versão em português para uso no Brasil do instrumento MTA-SNAP-IV de avaliação de sintomas de transtorno do déficit de atenção/hiperatividade e sintomas de transtorno desafiador e de oposição. *Revista de Psiquiatria Do Rio Grande Do Sul*, *28*(3), 290–297. doi:10.1590/S0101-81082006000300008

Miller, M., Loya, F., & Hinshaw, S. P. (2013). Executive functions in girls with and without childhood ADHD: Developmental trajectories and associations with symptom change. *Journal of Child Psychology and Psychiatry*, *54*(9), 1005–1015. doi:10.1111/jcpp.12074

Mulder, M. J., Bos, D., Weusten, J. M. H., van Belle, J., van Dijk, S. C., Simen, P., … Durston, S. (2010). Basic impairments in regulating the speed-accuracy tradeoff predict symptoms of attention-deficit/hyperactivity disorder. *Biological Psychiatry*, *68*(12), 1114–1119. doi:10.1016/j.biopsych.2010.07.031

O'Neill, S., Rajendran, K., Mahbubani, S. M., & Halperin, J. M. (2017). Preschool predictors of ADHD symptoms and impairment during childhood and adolescence. *Current Psychiatry Reports*, *19*(12). doi:10.1007/s11920-017-0853-z

O'Neill, S., Thornton, V., Marks, D. J., Rajendran, K., & Halperin, J. M. (2016). Early language mediates the relations between preschool inattention and school-age reading achievement. *Neuropsychology*, *30*(4), 398–404. doi:10.1037/neu0000247

Oliveira-Ferreira, F., Costa, D. S., Micheli, L. R., de Fátima Sílvia Oliveira, L., Pinheiro-Chagas, P., & Haase, V. G. (2012). School achievement test: Normative data for a representative sample of elementary school children. *Psychology & Neuroscience*, *5*(2), 157–164. doi:10.3922/j.psns.2012.2.05

Pham, A. V. (2013). Differentiating behavioral ratings of inattention, impulsivity, and hyperactivity in children. *Journal of Attention Disorders*, *20*(8). doi:674–683.doi:10.1177/1087054712473833

Plourde, V., Boivin, M., Brendgen, M., Vitaro, F., Robaey, P., Tremblay, R. E., & Dionne, G. (2018). Cognitive mechanisms underlying the associations between inattention and reading abilities. *Developmental Neuropsychology*, *43*(1), 92–105. doi:10.1080/87565641.2017.1422508

Polanczyk, G., Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The worldwide prevalence of ADHD: A systematic review and metaregression analysis. *American Journal of Psychiatry*, *164*(6), 942. doi:10.1176/ajp.2007.164.6.942

Polderman, T. J. C., Boomsma, D. I., Bartels, M., Verhulst, F. C., & Huizink, A. C. (2010). A systematic review of prospective studies on attention problems and academic achievement. *Acta Psychiatrica Scandinavica*, *122*(4), 271–284. doi:10.1111/j.1600-0447.2010.01568.x

Polner, B., Aichert, D., Macare, C., Costa, A., & Ettinger, U. (2014). Gently restless: Association of ADHD-like traits with response inhibition and interference control. *European Archives of Psychiatry and Clinical Neuroscience*, *265*(8), 689–699. doi:10.1007/s00406-014-0531-7

Pruim, R. H. R., Beckman, C. F., Oldehinkel, M., Osteerlan, J., Heslenfeld, D., Hartman, C. A., et al. (2019). An integrated analysis of neural network correlates of categorical and dimensional models of attention-deficit/hyperactivity disorder. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *4*, 472–483. doi:10.1016/j.bpsc.2018.11.014

Re, A. M., Mirandola, C., Esposito, S. S., & Capodieci, A. (2014). Spelling errors among children with ADHD symptoms: The role of working memory. *Research in Developmental Disabilities*, *35*(9), 2199–2204. doi:10.1016/j.ridd.2014.05.010

Rodrigues, J. C., Miná, C. S., & Salles, J. F. (2017). *Tarefa de leitura de palavras e pseudopalavras*. Editora Vetor.

Rogers, M., Hwang, H., Toplak, M., Weiss, M., & Tannock, R. (2011). Inattention, working memory, and academic achievement in adolescents referred for attention deficit/hyperactivity disorder (ADHD). *Child Neuropsychology*, *17*(5), 444–458. doi:10.1080/09297049.2010.544648

Rossi, A. S. U., Moura, L. M., De, Mello, C. B., De, Souza, A. A. L., De, Muszkat, M., & Bueno, O. F. A. (2015). Attentional profiles and white matter correlates in attention-deficit/hyperactivity disorder predominantly inattentive type. *Frontiers in Psychiatry*, *6*. doi:10.3389/fpsyt.2015.00122

Salles, J. F., Fonseca, R. P., Cruz-Rodrigues, C., Mello, C. B. D., Barbosa, T., & Miranda, M. C. (2011). Desenvolvimento do Instrumento de Avaliação Neuropsicológica Breve Infantil NEUPSILIN-INF. *Psico USF*, *16*(3), 297–305. doi:10.1590/S1413-82712011000300006

Salles, J. F., Piccolo, L. R., & Miná, C. S. (2017). *Manual do Instrumento de avaliação de leitura de palavras e pseudopalavras (LPI)*. São Paulo, SP: Vetor Editora.

Salles, J. F., Piccolo, L. R., Zamo, R. S., & Toazza, R. (2013). Normas de desempenho em tarefa de leitura de palavras/pseudopalavras isoladas (LPI) para crianças de 1º ano a 7º ano. *Estudos e Pesquisas em Psicologia*, *13*(2), 397–419. Retrieved from http://www.e-publicacoes.uerj.br/index.php/revispsi/article/view/8416/7313

Salles, J. F., Sbicigo, J. B., Machado, W. D. L., Miranda, M. C., & Fonseca, R. P. (2014). Análise fatorial confirmatória do instrumento de Avaliação Neuropsicológica Breve Infantil-NEUPSILIN-Inf. *Psico USF*, *19*(1), 119–130. doi:10.1590/S1413-82712014000100012

Sarver, D. E., Rapport, M. D., Kofler, M. J., Raiker, J. S., & Friedman, L. M. (2015). Hyperactivity in attention-deficit/hyperactivity disorder (ADHD): Impairing deficit or compensatory behavior? *Journal of Abnormal Child Psychology*, *43*(7), 1219–1232. doi:10.1007/s10802-015-0011-1

Sedó, M., de Paula, J. J., & Malloy-Diniz, L. F. (2015). *O Teste dos Cinco Dígitos*. São Paulo, Brazil: Hogrefe.

Sims, D. M., & Lonigan, C. J. (2013). Inattention, hyperactivity, and emergent literacy: Different facets of inattention relate uniquely to preschoolers' reading-related skills. *Journal of Clinical Child & Adolescent Psychology*, *42*(2), 208–219. doi:10.1080/15374416.2012.738453

Sørensen, L., Plessen, K. J., & Lundervold, A. J. (2011). The impact of inattention and emotional problems on cognitive control in primary school children. *Journal of Attention Disorders*, *16*(7), 589–599. doi:10.1177/1087054711417394

Stein, L. M. (1994). *TDE. Teste de desempenho escolar. Manual para aplicação e interpretação*. São Paulo, Brazil: Casa do Psicólogo.

Swanson, J. M. (1992). *School-based assessments and interventions for ADD students*. Irvine, CA: KC Publishing.

Swanson, J. M., Kraemer, H. C., Hinshaw, S. P., Arnold, L. E., Conners, C. K., Abikoff, H. B., … Hechtman, L. (2001). Clinical relevance of the primary findings of the MTA: Success rates based on severity of ADHD and ODD symptoms at the end of treatment. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*(2), 168–179. doi:10.1097/00004583-200102000-00011

Thorsen, A. L., Meza, J., Hinshaw, S., & Lundervold, A. J. (2018). Processing speed mediates the longitudinal association between ADHD symptoms and preadolescent peer problems. *Frontiers in Psychology*, *8*. doi:10.3389/fpsyg.2017.02154

van der Sluis, S., de Jong, P. F., & van der Leij, A. (2004). Inhibition and shifting in children with learning deficits in arithmetic and reading. *Journal of Experimental Child Psychology*, *87*(3), 239–266. doi:10.1016/j.jecp.2003.12.002

Walcott, C. M., Scheemaker, A., & Bielski, K. (2010). A longitudinal investigation of inattention and preliteracy development. *Journal of Attention Disorders*, *14*(1), 79–85. doi:10.1177/1087054709333330

Weiler, M. D., Bernstein, J. H., Bellinger, D. C., & Waber, D. P. (2000). Processing speed in children with attention deficit/hyperactivity disorder, inattentive type. *Child Neuropsychology*, *6*(3), 218–234. doi:10.1076/chin.6.3.218.3156