Associations of intellectual ability, inhibitory control, impulsiveness, cognitive flexibility and functional impairment in adults with ADHD Symptoms

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Abstract

Introduction: Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder with persistent levels of inattention, hyperactivity or impulsivity. Recommendations for ADHD diagnosis involve: six or more symptoms (or five considering adults), early childhood onset, presence of symptoms in two or more contexts and presence of functional impairment. Cognitive deficits, that affect inhibitory control, cognitive flexibility and impulsiveness, are present in ADHD and affect the course of the disorder. On the other hand, intellectual skill is a factor of protection to improve the development in people with ADHD. This article explores how traits relate to functional impairments are relevant to ADHD description in terms of behavioral expression of the cognitive profile. Method: Forty-nine adults, between 20 and 68 years old, with symptoms of inattention and hyperactivity/impulsivity compatible with ADHD, with more than 4 years of schooling and absence of chronic illness, took part of this study. The data was collected using screening instruments (ASRS-18, MMSE, and WASI) and main instruments (FDT, BIS-11, and EPF-ADHD). Results: The results have shown that higher intellectual indexes were associated with lower frequencies of academic impairment, while higher impulsivity levels, cognitive flexibility difficulties and inhibitory control, were associated with academic and social impairment. Conclusion: The results show that cognitive deficits were associated to impairment, in different life areas, of people with ADHD, and that some factors, as intellectual abilities, may prevent impairment in ADHD.

Keywords: Attention deficit hyperactivity disorder; Impulsiveness; Cognitive flexibility; Inhibitory control; intellectual ability; Functional impairment; Adults.

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder defined by impairing levels of inattention, disorganization, and/or hyperactivity-impulsivity. Inattention manifests

behaviorally in ADHD as avoid difficult tasks, lacking persistence, having difficulty sustaining focus and being disorganized, which is not due to challenge or lack of understanding. Hyperactivity refers to excessive motor activity; impulsivity reflects needs for immediate rewards or an inability to delay gratification, social intrusiveness and making important decisions without consideration. ADHD often persists into adulthood, with impairments of social, academic and occupational functioning (APA, 2014).

Functional consequences of ADHD are associated with reduced school performance and academic attainment, social rejection, especially in adults, poorer occupational performance and higher probability of unemployment as well as elevated interpersonal conflicts. Others as laziness, irresponsibility, or failure to cooperate are often interpreted as inadequate or variable performance of tasks that require sustained effort (APA, 2014). In order to better analyze the disorder, it is necessary to search for specific characteristics in related to chronicity, existence of comorbidities, and presence of impairments and severity, specifically to differ the symptoms of ADHD from another disorder. The presence of comorbidities and ADHD severity contributes to the delineation of the symptomatic profile and the treatment planning based on all present difficulties. Through the assessment of functional impairments, it is possible to observe the interaction between severity of symptoms and daily demands, which interfere with relationships and productivity (Kooij et al., 2016; Asherson et al., 2016).

Researches have shown that cognitive deficits found in ADHD can lead to learning disabilities, deficits in time perception, concept formation, planning, organization, ability to prioritize tasks, make decisions and focus attention. These characteristics might impair motivation and affect development, therefore, living with these deficits, from childhood to adulthood, implies impairment in adaptive functioning and in daily functioning. Thus, impaired cognitive functioning in people with ADHD frequently contributes to functional impairments in social, academic and occupational fields. Experiencing these impairments can affect self-esteem, self-efficacy and self-image (Barkley, 2008; Kooij et al., 2010; Thorell et al., 2017; Fuermaier, 2018).

Variability in neurocognitive aspects contributes to different ADHD presentations and degrees of impairment. Studies have shown strong association between ADHD and executive functioning deficits (including cognitive flexibility and inhibition), and impulsivity, that could be translated into behavioral variations, which include procrastination, late reward intolerance, time management difficulties and task shifting, as well as impulsive decisions and increased error occurrence. For all these reasons, people with ADHD may experience difficulties in life management, which could lead to problems in the academic, professional, family and social relations, increasing the risk of accidents, substance use and financial difficulties (Mosterba et al., 2015; Zalsman, Shilton, 2016; Canela et al., 2017; Fuermaier, 2018). On the other hand, there are neurocognitive conditions that could relieve the symptoms of ADHD and resulting damages. Intellectual abilities represent one of these conditions, which favor the development of compensatory strategies for dealing with one's own difficulties (Asherson et al., 2016; Thorell et al., 2017).

Understanding the connection between the cognitive mechanisms involved in ADHD symptomatology and the functional impairments may lead to a better understanding of how behavioral expressions of cognitive deficits occur in the disorder. Therefore, this study investigated the associacions between functional impairment levels and impulsiveness, inhibitory capacity, cognitive flexibility and intellectual abilities in adults with attention deficits and hyperactivity/impulsivity symptoms.

2. Method

2.1 Participants

Forty-nine adults, between 20 and 68 years old (M = 31.79, SD = 11.71), living in two cities of Brazil (São Paulo-SP e São Luis-MA), meet the inclusion criteria: ASRS-18 score > 24 points; IQ > 80 and absence of global cognitive functioning deficit suggestive of dementia, according to the MMSE. In addition, compatible conditions with the exclusion criteria, such as presence of no compensable visual or hearing deficit, presence of current neurological or psychiatric conditions (for the last 6 months), history of substance abuse or addiction and less than 4 years of schooling, verified at the initial interview. Participants taking ADHD medications continued in the study under the drug regimen prescribed.

The sample was predominantly female (n = 38, 77.6%), with years of education between 9 and 26 (M = 17, SD = 3.3), Elementary School (n = 1, 2%), High School (n = 24, 49%), University (n = 24, 49%). At the time of the survey, only two participants reported ADHD medications use. Regarding the number of frequent or very frequent symptoms of ADHD in the ASRS, considering the minimum required by DSM-5 for diagnosis, 26 participants (53.1%) reported 5 or more symptoms of inattention and / or hyperactivity / impulsivity. Among them, 11 participants had a predominance of inattention symptoms; 4 participants had predominance of hyperactivity / impulsivity. Part of the sample (n = 23, 46.9%) did not show at least 5 symptoms of inattention or hyperactivity / impulsivity but all of them had at least 25 points in ASRS-18 total score. Table1 summarizes demographic information and inclusion criteria of participants.

Table 1: Demographic information and inclusion critéria of participants.

Demographic	**n**		**%**	
Gender	Women: 38	Men: 11	Women: 77.6	Men: 22.44
ADHD Medication	Yes: 2	No: 47	Yes: 4.1	No: 44.90
Inclusion Criteria	**Mean**	**SD**	**Minimum**	**Maximum**
Education (years)	17.28	3,34	9	26
ASRS-18 total score	41.00	9,37	25	65
ASRS-18 symptoms of inattention	3.37	2,45	0	8
ASRS-18 symptoms of hyperactivity-impulsivity	4.55	4,00	0	9
MMSE	28.24	1,76	23	30
WASI IQ 2 subtests	98.55	9,96	80	121

Legend: ASRS= Adult Self-Report Scale/ MMSE= Mini-Mental State Examination/ WASI= Wechsler Abbreviated Scale of Intelligence. N= 49, 100% valid.

2.2 Instruments

Structured interview was used to verify inclusion and exclusion criteria by checking physical conditions, social, occupational and educational status, medical history and current health problems.

Adult Self-Report Scale (ASRS) is an adult self-assessment scale that checks for the presence of ADHD symptoms described in DSM-5 criteria. ASRS consists of 18 items divided into two parts that

describes symptoms of inattention and hyperactivity/impulsivity. Each participant evaluates the frequency (never, rarely, sometimes, often and very often, and respectively score 0 to 4) in which a particular situation occurs (Mattos et al., 2006). In the original study (Kessler et al., 2005) indicates that total scores greater than 24 suggest the presence of ADHD. However, it is possible, by checking the number of "often" and "very often" type answers, comparing the result with the minimum of symptoms required by the DSM-5 and thus obtaining information about ADHD presentations.

Mini-Mental State Examination (MMSE) is a screening tool for global cognitive functioning. It evaluates five cognitive domains, time and space orientation, immediate memory, recall, attention, calculus, recall, language and visuoconstructive ability. The maximum total score is 30 points, the school-based cutoff points proposed by Brucki et al. (2003). After a study of adults aged 16 to 92 years, are 20 points for illiterate people, 25 points for 1 to 4 years old, 26, 5 points for 5 to 8 years, 28 points for 9 to 11 years and 29 points for over 11 years (Brucki et al., 2003). Scores below the cutoff points may indicate pathological conditions, as dementia processes.

Wechsler Abbreviated Scale of Intelligence (WASI) assess the estimated IQ, obtained from Vocabulary and Matrix Reasoning subtests. The Vocabulary subtest is a verbal task of conceptualization, in which one must name and define items (figures and words). The Matrix Reasoning subtest is a nonverbal serial reasoning task to analyze a matrix after displaying a frame with a set of figures in which one is missing and choosing the one that best completes the set (Trentini et al., 2014).

Five Digit Test (FDT) evaluates executive functions (inhibitory control and cognitive flexibility) from the interference effect of conflicting information about numbers and quantities, assessing execution time and number of errors in four parts or components. Reading is the first component and requests subjects to name numbers from 1 to 5 as quickly as possible. On the second task (counting), they need to describe quantities from 1 to 5, subject should tell how many numbers are present in each stimulus, but do not read the numbers. The third component (choosing) involves a selective attention, and the subjects should not read the numbers, but tell how many numbers are present in each stimulus, in an incongruent condition. The last component (shifting) is similar to choosing, but for each of the five stimuli, there is one previous when the subject must read the stimulus numbers (de Paula et al., 2017). It allows to describe efficient speed and cognitive processing as focused attention, progressive task automation, and an ability to mobilize additional mental effort when the growing and difficult-to-use experimental series increases.

Barratt Impulsiveness Scale (BIS-11) assesses the level of impulsiveness, based on the model that is composed of motor impulsivity, attentional impulsivity, and non-planning impulsivity. The BIS-11 investigates impulsivity dimensions and impulsivity signals, based on the frequency of impulsivity, behaviors that should be classified as rarely or never, sometimes, usually or always, scored, respectively, from 1 to 4 points. The total score is the product of the sum of the weight of the answers. Brazilian studies show that high scores and percentiles indicate the presence of impulsive behaviors (Malloy-Diniz et al., 2015).

Functional Impairment Rating Scale for ADHD (EPF-ADHD) is applicable to the age group between 18 and 76 years (Oliveira & Nascimento, 2016). It aims to verify functional impairment associated with ADHD in adults, exploring nine areas of life: academic (8 items), professional (10 items), social (8 items), affective-sexual (8 items), domestic (7 items), financial (7 items), health (6 items), traffic (6 items) and

legal risk (5 items). For each of the 66 items, the participant have to answer how often the examples occur with them using the Likert scale "not applicable", "never", "rarely", "sometimes", "many times ","‟ always ". From the determination of the impacted areas (absence of impairment or impairment to mild, moderate or severe) it is possible to verify the impairment required by DSM-5 to identify ADHD.

2.3 Procedures

All participants provided consent according to University's Human Research Ethics Committee (number 2.339.715; CAAE: 77609117.2.0000.0084). First screening instruments (ASRS, WASI, MEEM and structured interview) searched for profiles according to the inclusion and exclusion criteria. Subsequently, EPF-ADHD, FDT and BIS-11 instruments evaluated the selected participants during four meetings of one hour each. The results entered into a Pearson correlation analysis, using the Statistical Package for the Social Sciences (SPSS), version 20.0.

In order to analyze performance in neuropsychological tests and self-assessment inventories, specific indices were selected. For the assessment of functional impairment in the academic, professional and social areas, the average frequency of functional impairment obtained with the EPF-ADHD was used. The estimated IQ of WASI was used as a measure of intellectual ability. Inhibition capacity and cognitive flexibility were evaluated through the execution times (in seconds) demanded by tasks in FDT, so that the longer the execution time, the greater the difficulty encountered during performance.

3. Results and Discussion

The Table 2 describes the results of neuropsychological tests and self-assessment inventories. It is possible to observe functional losses in academic, professional and social areas assesd by EPF-ADHD. The general results also points to signs of impulsiveness in the sample.

Table 2: Results (Mean ± SD; Minimum and Maximum) of neuropsychological tests and self-assessment inventories.

Indices	Mean	SD	Minimum	Maximum
Functional losses academic area	1.37	0.58	0	3.3
Functional losses professional area	0.97	0.47	0	2.0
Functional losses social area	1.23	0.51	0,4	2.5
Cognitive flexibility (seconds)	27.32	18.39	1	115
Inhibition (seconds)	14.57	8.61	0	45
Impulsiveness	70.69	10.78	51	102

n= 49, 100% valid.

The results showed a significant negative association between IQ and functional impairment in academic areas (r = -0.436, p = 0.002) with a medium magnitude effect. No associations were found between changes in IQ and frequency of functional impairment in the professional (r = 0.030, p = 0.840) and social (r = -0.044, p = 0.766) areas. Positive associations were observed between the cognitive

flexibility index and the frequency of functional impairment in the academic (r = 0.357, p = 0.012) and social (r = 0.422, p = 0.003) areas, both with medium magnitude effect. No associations were found between the cognitive flexibility index and the frequency of functional impairment in the professional area (r = -0. 049, p = 0.739). Inhibitory control indices were positively associated with the frequency of functional impairment in the academic (r = 0.357 and p = 0.012) and social (r = 0.360 and p = 0.011) areas, both with an effect of medium magnitude. No associations were found between inhibitory control indices and the frequency of functional impairment in the professional field (r = -0. 067, p = 0.649). The evaluation of impulsivity levels demonstrates positive associations between indices and frequencies of functional impairment in the academic (r = 0.374, p = 0.008) and social (r = 0.317, p = 0.027) areas, with average effects magnitude. There was no significant association between impulsivity indices and professional impairment (Table 3).

Table 3: Associations between evaluated cognitive indexes and life areas by EPF-ADHD.

Life Areas	**IQ**	
	Pearson's r	***p***
Academic	-0.436**	0.002
Professional	0.030	0.840
Social	-0.044	0.766

Life Areas	**Cognitive Flexibility**	
	Pearson's r	***p***
Academic	0.357*	0.012
Professional	-0.049	0.739
Social	0.422**	0.003

Life Areas	**Inhibition**	
	Pearson's r	***p***
Academic	0.357*	0.012
Professional	-0.067	0.649
Social	0.360*	0.011

Life Areas	**Impulsiveness**	
	Pearson's r	***p***
Academic	0.374**	0.008
Professional	-0.128	0.379
Social	0.317*	0.027

n= 49, 100% valid, * $p < 0.05$, ** $p < 0.01$.

The findings corroborate previous research results on the interaction between cognitive profile and their expression in life contexts and functional impairment. Asherson et al. (2016) reported that intellectual skills often act in favor of developing compensatory strategies. Cognitive profile may have a protective and compensatory effect in relation to functional impairment. Our results reinforce that IQ varied in the opposite direction to functional impairment in the academic area. In this study, the difficulties in cognitive flexibility and inhibitory control followed the same direction as functional impairments in the academic and social areas.

Cognitive flexibility and inhibitory ability are components of executive functions, frequently altered in ADHD cases. Canela et al. (2017) attribute to the executive functioning important participation in coping with day life situations, so deficits in this domain can cause functional difficulties. According to Goodman

et al. (2016), the perception of impairment depends directly on the interaction between ADHD symptoms and individual self-regulation abilities, adaptation to life changes in different contexts, support network and compensation levels. For them, even when life changes become easier and the impacts are no longer perceived intensely, it can continue to interfere in the level of satisfaction of these people´s lives. The association between impulsiveness traits and the presence of impairments also varies while increasing.

Physical and mental restlessness, mood swings, emotional dysregulation, distracted mental state, difficulty sleeping, difficulty coping with frustration (Asherson et al., 2016) exemplify impulsive behaviors observed in people with ADHD. These are all factors that interfere with productivity, since signs of impulsivity represent lack of focus, difficulty in inhibiting responses and low tolerance to delay gratifications. In terms of behavioral expression, these signs evidence attention deficit, cognitive instability, difficulties in self-control, planning, motor control and inhibiting reactive or automated responses (Malloy-Diniz et al., 2010). The predominance of negative or positive associations with the academic area configures another result constantly mentioned in the literature (Zalsman, Shilton, 2016; Kooij et al., 2010). This sector of life demands skill in organizing, planning and concentrating, often undersupplied in ADHD. On the other hand, the absence of associations related to losses, in the professional area, was contrary to the expected, since in most cases in our sample, no impact was verified by the interference of symptoms on productivity.

4. Conclusion

The results of this study demonstrated how much the neurocognitive profile deserves to be valued in the evaluation processes of ADHD, since individual variations of it can contribute to behavioral symptoms and functional impairment. These results are important for clinical practice, because it is through the observation of the behavioral symptoms, associated to cognitive assessment that is possible to know better the extension of problems and the degree of severity associated to ADHD.

5. Acknowledgement

This study was financed in part by Programa de Excelência Acadêmica (Proex) Processo n. 0653/2018 from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

6. References

American Psychiatric Association. (2014). DSM-5: Manual diagnóstico e estatístico de transtornos mentais. Artmed Editora.

Asherson, P., Buitelaar, J., Faraone, S. V., & Rohde, L. A. (2016). Adult attention-deficit hyperactivity disorder: key conceptual issues. The Lancet Psychiatry, 3(6), 568-578.

Barkley, R. A. (2009). Transtorno de déficit de atenção/hiperatividade: manual para diagnóstico e tratamento. Artmed Editora.

Brucki, S., Nitrini, R., Caramelli, P., Bertolucci, P. H., & Okamoto, I. H. (2003). Suggestions for utilization of the mini-mental state examination in Brazil. Arquivos de neuro-psiquiatria, 61(3B), 777-781.

Canela, C., Buadze, A., Dube, A., Eich, D., & Liebrenz, M. (2017). Skills and compensation strategies in adult ADHD–A qualitative study. PloS one, 12(9), e0184964.

de Paula, J. J., Oliveira, T. Dell'Oro, Querino, E. H. Gonçalves, & Malloy-Diniz, L. F. (2017). The Five Digits Test in the assessment of older adults with low formal education: construct validity and reliability in a Brazilian clinical sample. Trends in Psychiatry and Psychotherapy, 39(3), 173-179. https://dx.doi.org/10.1590/2237-6089-2016-0060

Fuermaier, A. B., Fricke, J. A., de Vries, S. M., Tucha, L., & Tucha, O. (2019). Neuropsychological assessment of adults with ADHD: a Delphi consensus study. Applied Neuropsychology: Adult, 26(4), 340-354.

Goodman, D. W., Mitchell, S., Rhodewalt, L., & Surman, C. B. (2016). Clinical presentation, diagnosis and treatment of attention-deficit hyperactivity disorder (ADHD) in older adults: a review of the evidence and its implications for clinical care. Drugs & aging, 33(1), 27-36.

Kessler, R. C., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E. V. A., ... & Ustun, T. B. (2005). The World Health Organization Adult ADHD Self-Report Scale (ASRS): a short screening scale for use in the general population. Psychological medicine, 35(2), 245-256.

Kooij, J. S., Michielsen, M., Kruithof, H., & Bijlenga, D. (2016). ADHD in old age: a review of the literature and proposal for assessment and treatment. Expert review of neurotherapeutics, 16(12), 1371-1381.

Kooij, S. J., Bejerot, S., Blackwell, A., Caci, H., Casas-Brugué, M., Carpentier, P. J., ... & Gaillac, V. (2010). European consensus statement on diagnosis and treatment of adult ADHD: The European Network Adult ADHD. BMC psychiatry, 10(1), 67.

Malloy-Diniz, L. F., Mattos, P., Leite, W. B., Abreu, N., Coutinho, G., de Paula, J. J., ... & Fuentes, D. (2010). Tradução e adaptação cultural da Barratt Impulsiveness Scale (BIS-11) para aplicação em adultos brasileiros. J Bras psiquiatr, 59(2), 99-105.

Malloy-Diniz, L. F., Paula, J. J. D., Vasconcelos, A. G., Almondes, K. M. D., Pessoa, R., Faria, L., ... & Corrêa, H. (2015). Normative data of the Barratt Impulsiveness Scale 11 (BIS-11) for Brazilian adults. Brazilian Journal of Psychiatry, 37(3), 245-248.

Mattos, P., Segenreich, D., Saboya, E., Louzã, M., Dias, G., & Romano, M. (2006). Adaptação transcultural para o português da escala Adult Self-Report Scale para avaliação do transtorno de déficit de atenção/hiperatividade (TDAH) em adultos. Archives of Clinical Psychiatry, 33(4), 188-194.

Mostert, J. C., Onnink, A. M. H., Klein, M., Dammers, J., Harneit, A., Schulten, T., ... & Franke, B. (2015). Cognitive heterogeneity in adult attention deficit/hyperactivity disorder: a systematic analysis of neuropsychological measurements. European Neuropsychopharmacology, 25(11), 2062-2074.

Oliveira, A. P. A. De; Nascimento, E. de. EPF-TDAH: Escala de prejuízos funcionais – TDAH. 1ª ed. São Paulo: Hografe, 1ª ed. 2016.

Sedó, M.; Paula, F.J.; Malloy-Diniz, L.F. (2017). O Teste dos cinco dígitos. Editora Hografe.

Thorell, L. B., Holst, Y., Chistiansen, H., Kooij, J. S., Bijlenga, D., & Sjöwall, D. (2017). Neuropsychological deficits in adults age 60 and above with attention deficit hyperactivity disorder. European Psychiatry, 45, 90-96.

Trentini, C. M.; Yates, D. B.; Heck, V. S. Escala de Inteligência Wechsler Abreviada (WASI). Casa do

Psicólogo.
Zalsman, G., & Shilton, T. (2016). Adult ADHD: A new disease? International journal of psychiatry in clinical practice, 20(2), 70-76.