Relation between executive function and academic achievement among children diagnosed with attention deficit and hyperactivity disorder

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Background
In spite of decades of progress in understanding attention-deficit hyperactivity disorder (ADHD) as a disorder of executive functions (EFs), there have been no significant number of studies exploring this executive dysfunction's effects on a child's daily life, more specifically the academic achievement domain, and it was long hypothesized that EFs affect child school performance and learning ability. Therefore, the identification of early, modifiable predictors of achievement can help guide efforts to improve the long-term success of many children and adolescents and to develop individualized educational strategies aimed at assisting children who struggle academically.

Patients and methods
This study examined different EF domains in a sample (*N*=100) of drug-naïve children aged 6–13 and having ADHD using the Barkley Deficits In Executive Functioning Scale-Children and Adolescents (BDEFS-CA). Moreover, all children were subjected to structured psychiatric interview as well as intelligence quotient testing and Conners' parent rating scale. Relations between complex EF and academic achievement were examined.

Results
Academic performance was highly correlated with intelligence quotient, whereas there is no significant difference between different subtypes of ADHD and EFs. The correlation between Conners' scale score signifying ADHD symptoms severity and academic achievement was insignificant. Finally, self-motivation EFs showed the highest significant correlation, suggesting a domain-general relation between complex EF and academic achievement.

Conclusion
Self-motivation is the main EF correlated with academic achievement in children with ADHD, and developing individualized educational programs for those children will improve scholastic achievement.

Keywords:
academic performance, attention-deficit hyperactivity disorder, executive functions

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Background

Executive functions (EFs) are among the hypothesized neuropsychological mediating agents in attention-deficit hyperactivity disorder (ADHD) (Barkley, 2005). The EF hypothesis in ADHD is supported by brain-imaging studies, finding structures purported to underlie the EFs compromised in ADHD, (Valera *et al.*, 2007) and by study findings in children, adolescents, and adults with ADHD to be impaired on measures of executive functioning compared with nonclinical counterparts (Nigg *et al.*, 2005).

Consequently, EF impairment appears to be a salient feature of ADHD. Studies have attempted to examine the proportion of individuals with ADHD who have an EF deficit (EFD) and report a range of 30–50% of children and adolescents with ADHD to have EFD (Loo *et al.*, 2007).

EFs play a central role in sustaining and calibrating the development of academic skills and in school performance in general; however, few studies have directly targeted EF as a predictor and/or correlate of school readiness and achievement (Visu-Petraa *et al.*, 2011). In the last decade, EFs have replaced the intelligence quotient as the most studied variable with respect to academic performance and that both currently have the same predictive capacity (Cortés Pascual *et al.*, 2019).

According to the EF model proposed by Miyake *et al.* (2008), which received the largest empirical support for

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adults and children after the age of 5 years, there are three main EF dimensions: updating, set-shifting, and inhibition (Best *et al.*, 2009).

These EFs represent essential ingredients for optimal academic functioning and are also one of the important potential sources of school dysfunction, as deficits in EF have been noted in ADHD in both mathematics and reading (McLean and Hitch, 1999). Recently, the link between EF and academic achievement has begun to be more systematically investigated, with EF seen as a multifaceted construct, related to multiple academic outputs (Mazzocco and Kover, 2007).

The link between ADHD and low academic performance can have different explanations linked to models based on different neuropsychological processes. One of these models highlights the cognitive conceptualization of ADHD, explaining it as a deficit in the EFs or processes that coordinate the cognitive cerebral functions, basically planning, inhibitory control, working memory, and cognitive flexibility. The model by Barkley (1997) offers a comprehensive explanation, arguing that the impairments in verbal and non-verbal working memory, motivation, and the processes of analysis/synthesis represent problems that correspond to insufficient self-regulation and deficient inhibitory control (Barkley, 1997).

As Preston *et al*. and colleagues (Preston *et al*., 2009) have shown, at least some of the academic difficulties experienced by children with ADHD are owing to their reduced capacity to inhibit and change their attention, rather than the presence of specific learning difficulties (Ana Miranda *et al.*, 2012).

Barry *et al*. (2002) explored to what degree the EFs of planning and flexibility and the severity of the ADHD symptoms predicted academic performance in mathematics, reading, and writing separately (Ana Miranda *et al.*, 2012).

There is a high significance of academic achievement for various life outcomes, such as academic and vocational success, income, and socioeconomic status (Jimerson *et al.*, 1999). The fact that educational differences are a main source of social disparities highlights the importance of interventions supporting scholastic achievement, and process-based cognitive training in the domains of working memory and EFs may enhance school-relevant abilities as well as academic achievement (Titz and Karbach, 2014).

Patients and methods

Study design

This is a cross-sectional study. Ethics committee approuval statement: The ethical committee of alexandria university has approuved this research and a verbal consent was taken from parents of participant children.

Study setting

This study was carried out on children attending the Child and Adolescent Psychiatry Outpatient Clinic, El Hadara University Hospital during 2018.

Target population

A total of 100 children diagnosed with attention-deficit hyperactivity disorder were included.

Inclusion criteria

The following were the inclusion criteria:

(1) Age: 6–13 years.
(2) Both sexes.
(3) Diagnoses: ADHD according to the DSM–IV-TR diagnostic criteria as assessed by K-SADS and psychometric tests (Kaufman*et al.*, 1997).
(4) Informed and written consent of all the children's parents and children's ascent.
(5) Drug-naive children.

Exclusion criteria

The following were the exclusion criteria:

(1) History of any sensory impairment.
(2) Diagnosis of learning disability.
(3) History of intellectual disability.
(4) History or present pharmacological treatment for ADHD.

Methods

The studied children were subjected to the following:

(1) History taking:
    (a) Demographic data, such as age of onset of symptoms, developmental history, previous medical and surgical history, and family history.
(2) Physical and neurological examination.
(3) Psychiatric assessment using structured interview with DSM-V criteria for diagnosis.
(4) Psychometric assessment:
    (a) Intelligence quotient (IQ) testing using Stanford Binet test (Coolican*et al.*, 2008).
    (b) Conners' parent rating form for ADHD severity assessment (Conners*et al.*, 1998).

(c) Barkley deficits in executive functioning scale-children and adolescents (BDEFS-CA) (Barkley, 2012).

It provides a valid assessment of executive functioning deficits in daily life activities with an age range of 6–17 years.

Format of parent-report rating scale (long form):

The scale was translated into Arabic version and then revised with a jury of two psychiatry professors and one linguistic specialist, and then it was tested for its reliability regarding Arabic language using Cronbach's α, as shown in Table 1.

(1) Assessment of scholastic achievement of the children was done through their final grades, where excellent grade scores = 85–100%, good grade scores = 70–84%, below average scores = 50–69%, and poor for scores = <50% or failed.

Results

Table 1 the scale items focused on problematic symptoms (deficit measurement) rather than on positive or normative EF functioning, The long forms of the BDEFS and the BDEFS-CA are scored by calculating the totals for each of the five scales: Self-Management to Time, Self-Organization and Problem-Solving, Self-Restraint, Self-Motivation, and Self-Regulation of Emotion.

Additionally, the instrument yields a total executive functioning summary score (the total of the five scales), symptom count (number of items rated as occurring often or very often), and an ADHD-executive function index score (with higher score indicating greater likelihood for a clinical diagnosis of ADHD).

Table 2 a comparison showing that there is no significant relation between Conner's score (denoting symptom severity of ADHD) and scholastic achievement.

Table 3 showed significant correlation between IQ and school achievement was found in the total sample.

Table 4 shows a comparison between different subtypes of ADHD regarding executive functions deficit showing no significant difference in the five different executive function domains among the three subtypes.

Table 5 showed that EFs affection were all significantly related to scholastic achievement being worst in poor

Table 1 Reliability statistics for Barkley scale for executive functions

Cronbach's Alpha	Number of items	
0.955	13	Time management
0.939	14	Problem solving and self organization
0.952	13	Self control
0.947	14	Self actualization
0.973	16	Emotional stability
0.978	70	Overall

Table 2 Relation between academic achievement and Conner's scale

Conner's scale	Academic achievement [*n* (%)]		χ^2	*P*
	Good outcome (*n*=43)	Bad outcome (*n*=57)		
No	0	0		
<20	14 (32.6)	13 (22.8)	1.863	0.394
20–25	17 (39.5)	30 (52.6)		
>25	12 (27.9)	14 (24.6)		

P, *P* value for association between academic achievement and Conner's scale.

Table 3 Relation between academic achievement and intelligence quotient function

IQ	Academic achievement [*n* (%)]				χ^2	^{MC}P
	Excellent (*n*=12)	Good (*n*=31)	Below average (*n*=33)	Poor (*n*=24)		
80–90	0[a]	1 (3.2)[a]	5 (15.2)[a]	10 (41.7)[b]		
90–110	6 (50)[a]	24 (77.4)[b]	27 (81.8)[b]	14 (58.3)[b]	36.233*	<0.001*
110–119	6 (50)[a]	6 (19.4)[b]	1 (3)[c]	0[c]		

Frequency with common letters are not significant (i.e. different letters are significant). MC, Monte Carlo; *P*, *P* value for association between academic achievement and intelligence quotient. *Statistically significant at $P \leq 0.05$

Table 4 Relation between EF and different ADHD subtypes (*n*=100)

	Diagnoses [*n* (%)]			χ^2	*P*
	Combined ADHD (*n*=45)	Hyperactive ADHD (*n*=32)	Inattentive ADHD (*n*=23)		
Time management EF					
No	20 (44.4)	13 (40.6)	10 (43.5)	0.144	0.945
Yes	25 (55.6)	19 (59.4)	13 (56.5)		
Problem solving and self-organization EF					
No	26 (57.8)	21 (65.6)	12 (52.2)	1.051	0.591
Yes	19 (42.2)	11 (34.4)	11 (47.8)		
Self-restraint executive function					
No	1 (2.2)	3 (9.4)	3 (13.0)	3.388	^{MC}P=0.171
Yes	44 (97.8)	29 (90.6)	20 (87.0)		
Self-motivation EF					
No	15 (33.3)	17 (53.1)	8 (34.8)	3.391	0.184
Yes	30 (66.7)	15 (46.9)	15 (65.2)		
Emotional regulation EF					
No	13 (28.9)	6 (18.8)	8 (34.8)	1.893	0.388
Yes	32 (71.1)	26 (81.3)	15 (65.2)		

ADHD, attention-deficit hyperactivity disorder; EF, executive function; MC, Monte Carlo; *P*, *P* value for association between ADHD subtypes and EF.

Table 5 Relation between academic achievement and different executive function

	Academic achievement [*n* (%)]				χ^2	*P*
	Excellent (*n*=12)	Good (*n*=31)	Below average (*n*=33)	Poor (*n*=24)		
Time management EF						
No	5 (41.7)	11 (35.5)	13 (39.4)	14 (58.3)	3.200	0.362
Yes	7 (58.3)	20 (64.5)	20 (60.6)	10 (41.7)		
Problem-solving and self-organization EF						
No	10 (83.3)	19 (61.3)	18 (54.5)	12 (50)	4.079	0.253
Yes	2 (16.7)	12 (38.7)	15 (45.5)	12 (50)		
Self-restraint executive function						
No	1 (8.3)	1 (3.2)	3 (9.1)	2 (8.3)	1.399	^{MC}P=0.740
Yes	11 (91.7)	30 (96.8)	30 (90.9)	22 (91.7)		
Self-motivation EF						
No	11 (91.7)^{a}	26 (83.9)^{a}	3 (9.1)^{b}	0^{b}	67.344*	<0.001*
Yes	1 (8.3)^{a}	5 (16.1)^{a}	30 (90.9)^{b}	24 (100)^{b}		
Emotional regulation EF						
No	5 (41.7)	11 (35.5)	7 (21.2)	4 (16.7)	4.303	0.231
Yes	7 (58.3)	20 (64.5)	26 (78.8)	20 (83.3)		

Frequency with common letters are not significant (i.e. different letters are significant). EF, executive function; MC, Monte Carlo; *P*, *P* value for association between academic achievement and EF. *Statistically significant at $P \leq 0.05$.

scholastic levels and best with excellent scholastic levels where self- motivation EF was the highest EF to be significantly related to poor scholastic achievement to be affected in 100% of children with poor scholastic achievement, while affecting 91.7% in case of self-restraint EF, 83.3% in case of emotion regulation EF, 50% in case of problem solving EF and 41.7% in case of time management EF.

Discussion

The finding of the study showed that: 12% of the children had excellent achievement, 31% had good achievement, 33% had below average achievement, and 24% had poor achievement. This was similar to literature were symptoms of ADHD significantly affects scholastic achievements (Loe and Feldman, 2007), and this significant academic underachievement, poor academic performance, and educational problems can be explained In terms of impairment of body activity limitations, and in terms of restrictions in social participation and the deficits in executive functions needed for tasks requiring planning, organization and time management (Biederman *et al.*, 1996).

In this study, there was no significant correlation between the severity of ADHD as assessed by

Conners' rating scale and scholastic achievement. This could be explained by the fact that in our study, we excluded children with comorbidities including learning disability and other comorbidities, and in an Egyptian study by Abdallah *et al.* (2020), it was found that poor academic achievement was significantly correlated to presence of comorbidities with ADHD.

As expected in the current study, IQ was significantly correlated with scholastic achievement. IQ was correlated either directly or indirectly with problem solving and educational performance. Therefore, a student with a high IQ and problem-solving skills is expected to have good results in his/her educational performance (Jalili et al., 2018).

Time management EF

Time management was affected in 57% of children with no significant difference between affection in the three subtypes of ADHD. Similar to the present results, Hosenbocus and Chahal (2012) found that many of the executive dysfunctions are found in children with ADHD including difficulties with priority and time management, planning and organization, initiating and completing tasks in a timely manner, difficulty shifting cognitive set, a high level of procrastination, forgetfulness, and poor working memory (Hosenbocus and Chahal, 2012).

Problem solving (self-organization) EF

It affects 41% of children with no significant difference between different subtypes of ADHD. In this work, no significant association was found between problem solving and low school achievement, affecting 50% of children with poor achievement. However, considering the group of below-average achievement, the percentage together with poor achievement will raise to reach 37% of the sample. Actually, this insignificant association in the studied group might be explained by the fact that we excluded all children with learning problems and below-average IQ.

Self-restraint EF (inhibition)

In our work, self-restraint was significantly affected in children with ADHD, affecting 93% of children (there was no significant difference in all EF affection between three subtypes of ADHD as found by previous studies) (Aly *et al.*, 2015), and this result was repeated in previous study findings and agrees with the body of research showing that executive dysfunction in the form of impaired response inhibition remains the most prominent cognitive theory of ADHD (Roth and Saykin, 2004).

Although self-restraint impairment is a core feature of ADHD, it is not significantly associated with academic achievement as it affects almost all children even those with excellent performance which might be explained by the fact that excellent performance in those children is due to private lessons, which allow the child a degree of freedom while attending lessons.

Self-motivation EF

The present work showed that self-motivation was significantly affected in 60% of the children with ADHD, with no difference among the three subtypes of ADHD. It was also associated with poor school achievement. Similarly, Knouse *et al*. (2014) measured EF using the BDEFS, and they found that self-motivation was the strongest predictor of grade point average (GPA), with management of time, organization, and self-restraint also having positive relationships with GPA.

Emotion regulation EF

The present study showed that emotion regulation was significantly affected in children with ADHD, affecting 73% of them. This finding might explain the emotional lability symptom associated with ADHD. One study (150) showed that 80% or more of adults with ADHD report significant levels of emotional lability, often severe, causing impairments beyond that accounted for by inattention, hyperactivity, or impulsivity, and drug treatments for ADHD have all been shown to improve symptoms of emotional lability. In spite of its presence in 83% of children with poor academic performance, this was not significantly correlated with school performance, which could be justified by the agreement that emotional dysregulation is a core feature of the diagnosis of ADHD regardless of the scholastic achievement and to the social fact of our community that students relay on private lessons which allow a degree of flexibility of emotional expression. Similarly, a study concluded that because children with ADHD are reported to do better with one-on-one instruction, smaller class size makes intuitive sense. Teachers perceive class size to be one of the major barriers to inclusion of students with ADHD in regular education (Loe and Feldman, 2007).

Conclusion

EFs are affected in all three subtypes of ADHD, with no significant difference among them. The degree of severity of ADHD is not a predictor of academic achievement, whereas IQ is significantly correlated to academic performance.

Finally, self-motivation is the main EF correlated to academic achievement in children suffering from ADHD and developing individualized educational programs for those children will improve scholastic achievement.

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Conflicts of interest
There are no conflicts of interest.

References

Abdallah SI, Salah-Eldeen GM, Abo Hashem HM, Aiad OA (2020). Child characteristics associated with comorbidities among children diagnosed with attention-deficit hyperactivity disorder. Egypt J Psychiatr 41:19–24.

Aly HY, Effat SMA, Azb HM, Abd Elsamei AM (2015). Executive functions among Egyptian children with attention deficit hyperactivity disorder and reading disabilities. Middle East Curr Psychiatry 22:97–106.

Ana Miranda A, Carla C, Inmaculada F, María-Jesús P (2012). Executive Functioning and Motivation of Children with Attention Deficit Hyperactivity Disorder (ADHD) on Problem Solving and Calculation Tasks. Revista de Psicodidáctica 17:51–71.

Barkley R (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. Psychol Bull 121:65–94.

Barkley RA (2005). ADHD and the Nature of Self-Control. New York, NY: Guilford Press.

Barkley RA (2012). Barkley Deficits in Executive Functioning Scale – Children and Adolescents (BDEFS-CA). American Psychological Association: Guilford Press.

Barry T, Lyman R, Klinger LG (2002). Academic underachievement and attention-deficit/hyperactivity disorder: the negative impact of symptom severity on school performance. J Sch Psychol 40:259–283. doi: 10.1016/S0022-4405(02)00100-0.

Best JR, Miller PH, Jones LL (2009). Executive functions after age 5: changes and correlates. Dev Rev 29:180.

Biederman J, Faraone S, Milberger S, Guite J (1996). A prospective 4-year follow-up study of attention-deficit hyperactivity and related disorders. Arch Gen Psychiatry 53:437–446.

Conners CK, Sitarenios G, Parker JD, Epstein JN (1998). The revised Conners' Parent Rating Scale (CPRS-R): factor structure, reliability, and criterion validity. J Abnorm Child Psychol 26:257–268.

Coolican J, Bryson SE, Zwaigenbaum L (2008). Brief Report: Data on the Stanford–Binet Intelligence Scales (5th ed.) in Children with Autism Spectrum Disorder. J Autism Dev Disord 38:190–197.

Cortés Pascual A, Muñoz NM, Robres AQ (2019). Executive functions and academic performance. Front Psychol 10:1580.

Hosenbocus S, Chahal R (2012). A review of executive function deficits and pharmacological management in children and adolescents. J Can Acad Child Adolesc Psychiatry 21:223–229.

Jalili A, Hejazi M, Fomani GE, Morovvati Z (2018). The correlation between IQ with educational performance and problem solving mediation. J Health Promot Manage 7:XX.

Jimerson S, Egeland B, Teo A (1999). A longitudinal study of achievement trajectories: factors associated with change. J Educ Psychol 91:116–126.

Kaufman J, Birmaher B, Brent D, Rao U, Flynn C, Moreci P, *et al.* (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): initial reliability and validity data. J Am Acad Child Adolesc Psychiatry 36:980–988.

Knouse LE, Feldman G, Blevins EJ (2014). Executive functioning difficulties as predictors of academic performance: examining the role of grade goals. Learn Individ Differ 36:19–26.

Loe IM, Feldman HM (2007). Academic and educational outcomes of children with ADHD. J Pediatr Psychol 32:643–654.

Loo SK, Humphrey LA, Tapio T, Moilanen IK, McGough JJ, McCracken JT, *et al.* (2007). Executive functioning among finnish adolescents with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 46:1594–1604.

Mazzocco MMM, Kover ST (2007). A longitudinal assessment of executive function skills and their association with math performance. Child Neuropsychol 13:18–45.

McLean JF, Hitch GJ (1999). Working memory impairments in children with specific arithmetic learning difficulties. J Exp Child Psychol 74:240–260.

Miyake A, Friedman NP, Young SE, DeFries JC, Corley RP, John K (2008). Individual differences in executive functions are almost entirely genetic in origin. Hewitt Published in final edited form as: J Exp Psychol Gen 137:201–225. doi: 10.1037/0096-3445.137.2.201.

Nigg JT, Willcutt EG, Doyle AE, Sonuga-Barke EJ (2005). Causal heterogeneity in attention-deficit/hyperactivity disorder: do we need neuropsychologically impaired subtypes? Biol Psychiatry 57:1224–1230.

Preston AS, Heatpn S, McCann S, Watson WD (2009). The Role of multidimensional attentional abilities in academic skills of children with ADHD. J Learn Disabil 42:240–249. doi: 10.1177/0022219408331042.

Roth RM, Saykin AJ (2004). Executive dysfunction in attention-deficit/hyperactivity disorder: cognitive and neuroimaging findings. Psychiatr Clin North Am 27:83–96.

Titz C, Karbach J (2014). Working memory and executive functions: effects of training on academic achievement. Psychol Res 78:852–868. doi: 10.1007/s00426

Valera EM, Faraone SV, Murray KE, Seidman LJ (2007). Meta-analysis of structural imaging findings in attention-deficit/hyperactivity disorder. Biol Psychiatry 61:1361–1369.

Visu-Petraa L, Cheie L, Benga O, Miclea M (2011). Cognitive control goes to school: the impact of executive functions on academic performance. Proc Soc Behav Sci 11:240–244.