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Hassan Shahrokhi[1], Mehdi Tehrani-Doost[2], Zahra Shahrivar[2], Sara Farhang[3] and Shahrokh Amiri[4]*

[1]Child and Adolescent psychiatrist, Research Center of Psychiatry and Behavioral Sciences, Tabriz University of medical sciences, Tabriz, Iran
[2]Associate Professor of Child and Adolescent Psychiatry, Department of Child and Adolescent Psychiatry, Tehran University of Medical Science, Tehran, Iran
[3]Assistant professor of Psychiatry, Research Center of Psychiatry and Behavioral Sciences, Tabriz University of Medical Sciences, Tabriz, Iran
[4]Professor of Child and Adolescent Psychiatry, Research Center of Psychiatry and Behavioral Sciences, Tabriz University of Medical Sciences, Tabriz, Iran

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***Corresponding author:** Shahrokh Amiri, Doctor, Department of Psychiatry, Razi university Hospital, Elgoli Boulevard, Tabriz 51677, East Azerbaijan, Iran, Tel: +98+413+3803353; E-mail: Amirish@tbzmed.ac.ir

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Research Article

Deficits of Executive Functioning in Conduct Disorder and Attention Deficit/Hyperactivity Disorder

Abstract

Background: To investigates executive functioning in Conduct disorder with comorbid ADHD.

Methods: Participants were adolescent males with ADHD, CD with comorbid ADHD and healthy controls. Executive functioning were assessed using Go/No go task, Iowa gambling test and selected tests from CANTAB.

Results: During the SWM test, CD+ADHD group had the tendency to revisit boxes with a token compared to controls. CD+ADHD patients had a significantly higher total error compared to controls in ID/ED set shift. They also needed more moves in SOC compared to controls and solved a significantly lower number of problems compared to ADHDs and controls. They had a lower delay time for choosing risky cards of Iowa.

Conclusion: CD+ADHD is associated with a broad range of deficits in executive functioning, compared to healthy controls as well as group with ADHD. ADHD group seem to have an intermediate performance compared to CD+ADHD and control groups in several measures.

Introduction

The spectrum of the behaviors associated with Conduct disorder (CD) is among the major reasons for referral of child and adolescent to psychiatric clinics. CD is characterized by violence against rights of others and the social norms. These emotional and behavioral problems involve not only the family but the health system and the community as well [1-3]. The burden of the disorder may continue to adulthood mostly contributing to occupational and marital problems [4]. It has been the matter of interest for investigations consequently but there are still several unclear issues about the classification, psychopathology and the treatment.

There is no pathognomonic sign or symptom for CD and the diagnosis is based on a series of criteria. Efforts have been made to find the etiology of this heterogeneous condition through the physiological, neuroendocrine, psychological, cognitive and sociological factors [5,6]. Several studies have particularly investigated the neuropsychological deficits that may influence the expression of violent and/or aggressive behavior. Studies support such hypothesis by showing impairments in their sensitivity to punishment and reward [7], or problems in decision making [8]. The matching neurobiological and functional neuroimaging evidences suggest that there are abnormalities in the orbitofrontal, superior temporal, cingulate, and limbic brain regions of adults with antisocial behavior and adolescents with conduct disorder [9-11]; regions that are known to be responsible for supervisory cognitive processes. The importance of these researches is not just restricted to depiction of the etiology or an endophenotype. Knowing the executive deficits will also guide the therapeutic approaches [12]. For instance; a therapy based on behavioral conditioning (e.g. parent management training) will not reach the goal when the patient is not sensitive enough to punishment and reward.

Controversy exists about problems in executive abilities of these patients and whether if it is restricted to a very common comorbidity of CD that is attention deficit /hyperactivity disorder (ADHD) [13]. Similarity of symptoms and neurocognitive characteristics of these two disorders put forward the question that whether these are two distinct conditions just with a high comorbidity rate or if these can be considered as an entity. A twin study indicated that conduct problems and ADHD share a common genetic etiology with comorbid CD + ADHD being a more severe subtype in terms of genetic loading and clinical

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severity [14]. This connection is reflected in the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) as well, where hyperkinetic disorders are not completely separated from conduct disorders. However reports are not exclusively consistent in the literature [15], and their symptoms are quite distinct in DSM-IV TR.

The objective of the present study was to compare the executive abilities of carefully selected patients with comorbid CD and ADHD to a group of patients with pure ADHD and a healthy comparison group and appraise the similarities.

Materials and Methods

This cross-sectional study was approved by the ethnic committee of Tehran University of medical sciences and a written consent was obtained from parents or care givers of children.

Participants

The study was designated to assess children in three age-matched groups. The group of children with CD and ADHD were selected from a Juvenile correction and rehabilitation center. CD was the early onset type in all of the cases. One hundred and seven children were evaluated and those fulfilling the inclusion criteria were enrolled as described later. The group with ADHD was recruited from child and adolescent psychiatry clinic and the healthy controls were randomly selected form the list of students within desired age group from the same region. Table 1 describes their age, IQ and years of education. All were Iranian male.

The diagnosis of CD and ADHD was made by a semi-structured interview based on the Kiddie Schedule for Affective Disorders and Schizophrenia-Present and Lifetime Version (K-SADS-PL) which the validity and reliability has been established in Farsi language before [16]. The Conner's parents rating scale was used to determine the symptoms of ADHD.

Table 1: Comparison of age, IQ and behavioral problems in patients with CD+ADHD, ADHD and the controls, as mean (SD).

	CD + ADHD (n=25)	ADHD (n=25)	Control (n=20)	p
Age (years)	16.36 (1.14)	16.14(1.22)	16.59(0.97)	0.449
IQ	108.76 (9.07)	111.85 (9.31)	112.85 (1.88)	0.281
Year of education	6.84 (1.82)	9.65 (1.88)	9.50 (1.88)	<0.0005
Adolescent anger questionnaire				
Instrumental Anger	50.40 (8.04)	46.85 (5.57)	45.00(4.33)	0.019
Reactive Anger	48.24 (10.60)	53.55 (8.52)	40.55(7.21)	0.043
Anger Control	52.44 (8.04)	53.45(7.941)	52.50(8.16)	0.901
Total score	47.16 (9.56)	47.00 (60.3)	44.40 (5.86)	0.420
Conners parents rating scale- revised				
Oppositional	66.88 (13.97)	44.60(14.17)	56.15 (9.99)	0.016
Cognitive problems/ Inattention	64.35 (10.56)	65.56 (9.78)	51.50 (7.11)	<0.0005
Hyperactivity	79.43 (12.16)	79.95(13.59)	66.50(15.86)	0.009
ADHD index	66.65 (10.96)	70.25(11.48)	55.65 (9.53)	0.001

Patients were excluded from the study in the presence of somatic and/or neurological disorders, another definite psychiatric diagnosis on axis I (reaching full DSM IV-TR criteria), evidences for sub threshold symptoms of a psychiatric diagnosis (i.e. not reaching full criteria) other than ADHD/CD, use of psychiatric medications in recent two weeks (except for methylphenidate for patients with ADHD which should be discontinued 48hours prior to evaluations) and intellectual disability (IQ score less than 90 by the Rion quiz). The children were categorized and introduced for neuropsychological evaluations subsequently. Efforts were made to reduce the effect of tiredness on the results by giving a rest and the procedure was carried out in two separate sessions with cognitional tests completed at the beginning of sessions. Each session lasted for 40-60 minutes.

K-SADS-PL was carried out for selecting controls as well as a thorough neurological examination. Any psychiatric conditions resulted in exclusion from this group.

Measures

Cambridge Neuropsychological Test Automated Battery (CANTAB®) [17], evaluates several aspects of cognitional functioning. This computerized test is independent from language and culture. Five selected tests of CANTAB were administered to address the goal of this study as described below.

(1) *Motor screening task (MOT)* and *(2) Big/little circle (BLC)* tests which are classified as induction tests in CANTAB (results are not shown)

(3) Spatial working memory (SWM) test is sensitive to function of frontal lobe and measures the ability to maintain spatial information and manipulating them in nonverbal working memory. Outcome includes errors and the strategy. Participants have to find blue tokens inside "boxes" which will increase in number step by step. Outcome measures include within errors (touching boxes that have been found to be empty), between errors (revising boxes after finding a token), total errors (sum of both) and the strategy.

(4) Stockings of Cambridge (SOC) is another measure of frontal lobe function. The aim is to arrange a set of colored balls as a copy of a certain pattern by moving one ball at a time. SOC measures the participants' spatial planning ability. The test measures the problems solved in minimal moves, mean of attempted moves and latency of responses (initial and subsequent thinking time).

(5) The base of the *Intra/extra dimensional set shift (IED)* is similar to Wisconsin card sorting test [18], and reflects the visual discrimination, attention set formation maintenance and shifting of attention. It has also been used to evaluate problem solving skills [19], and abstraction-flexibility [20]. The test comprises of white lines and colored shapes. The correct stimulus in each stage is trained by feedbacks. The correct answer depends on shapes at the beginning. In the next step the lines are considered as well and then an "intra dimensional" change happens and the shapes remain the only

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relevant dimension. It is followed by an "extra dimensional" shift and stimuli that used to be unrelated (the lines) become the base for the correct answer. The outcomes are errors (including pre-ED and ED shift errors), initial concentration, numbers of trials and completed stages.

The Go/No go task measures the impulsivity and response control. Two stimuli will be randomly presented on a screen and the participant is asked to press a key after seeing one of them but not the other one. Six variants were used. In V_1 two circles (blue and yellow) were presented for 1200_{ms}. The same stimuli were presented for 300_{ms} with a delay of 900_{ms} (V_2) and then for 800_{ms} with a delay of 1300_{ms} V_3. The stimuli are presented for 300_{ms} (900_{ms} delay) in V_4, V_5 and V_6 but stimuli change to a cross and a circle in V_5 and two black circles in V_6. Outcomes are score of Go trials, score of No Go trials, mean Go reaction time and mean No Go false reaction time.

Iowa gambling test (IGT) evaluates contingency learning based on the cumulative effect of reward and punishment. This type of decision making is related to the medial frontal lobe and the amygdala is probably involved as well [21]. This test is designated as a virtual game with 4 decks of cards (A,B,C and D) and evaluates the ability of participant in tendency for choosing cards with lower benefits at present (and lower risk in the future i.e. "good cards") opposed to cards with higher benefits at present and higher further risks and damage (bad cards). They were told that some decks are worse than others and were informed of the remaining amount of money after each card was selected. A global outcome score was calculated by subtracting the total number of cards selected from the disadvantage decks (A + B) from the total number of cards selected from the advantage decks (C + D). The delay before choosing from each deck of cards is also recorded separately. An alternative score has been proposed in our study population because of cultural characteristics [22,23], who seem to be more sensitive to rate of loss rather than its amount as (B+D) – (A+C).

Raven's progressive matrices consist of diagrams with missing parts which participants are asked to complete them by choosing from a series of pictures. Successful attempts are the basis for calculating the intellectual ability. The test is a measure of abstract reasoning and evaluates the ability for comparison and reorganization [24].

Adolescent anger rating scale (AARS) assesses the frequency and intensity of anger expression in adolescents ages 11 to 19 years. The test reports a total anger score and the subscales of instrumental anger, reactive anger and anger control as response patterns with parameter estimates were all above 0.30 (ranging from 0.57 to 0.70 for Reactive Anger, 0.37 to 0.78 for Instrumental Anger, and 0.38 to 0.83 for Anger Control) [25,26]. The test was completed by adolescents.

Conners parents rating scale-revised (CPRS-R) takes information about behavioral problems of children aged 13 to 17 years based on parental reports [27]. The test has comprehensive symptom coverage for ADHD based on DSM IV-TR. The subscales of interest were oppositional behavior, cognitive problems/ inattention, hyperactivity and ADHD index. Psychometric properties are described in details for separate age groups and gender and have introduced it as a valid and reliable tool for both research and clinical purposes [27].

Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children--Present and Lifetime Version (K-SADS-PL) is a guide for a semi-structured interview evaluating present and past psychopathology in children and adolescents based on DSM-IV criteria [27], except for autistic spectrum. All of the children were evaluate by a same psychiatrist in this study.

Statistical analysis

Data were analyzed by SPSS 11.5 for Windows software and are expressed as the mean± SD. Statistical significance was calculated using Chi-square, ANOVA or corresponding non-parametric tests according to results of the normal probability plots. Multiple comparisons were done consequently (Bonferroni, Games-Howell or Wilcoxon) to determine statistical significance of comparisons. Statistical significance was defined as $p< 0.05$.

Results

From the total of 107, Twenty five patients diagnosed with CD + ADHD, 25 with ADHD and 20 controls fulfilled the criteria and completed the study. IQ score was not different between the three groups but children with CD + ADHD had significantly lower years of education.

Behavioral assessments

Table 1 describes results of the behavioral assessments. While no difference was found in the total score of anger and score of anger control between groups, the score of instrumental anger was significantly higher in patients with CD + ADHD compared to controls ($p < 0.05$) while the score of anger control was significantly lower in ADHD group than controls ($p < 0.05$).

Oppositional behavior was significantly higher in CD + ADHD group compared to controls ($p < 0.05$) but the difference between the ADHD group and controls did not reach the significance. Both ADHD and ADHD + CD groups scored higher in cognitive problems/Inattention subscale compared to controls (both $p<0.001$) but the difference between these group was not significant. The hyperactivity subscale was significantly higher only in comparison of CD + ADHD group with controls ($p < 0.01$). ADHD index was not significantly different between ADHD group and CD+ADHD but ADHD group ($p<0.001$) and CD+ADHD group ($p < 0.01$) scored higher than controls.

Executive functioning measured by CANTAB test

Results are described in table 2. No significant difference was observed in results of BLC or MOT.

During the SWM test, CD+ADHD group had the tendency for more "between errors" compared to controls which reached

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the significance in 4- and 6-box problems ($p < 0.01$) and the difference decreased in 8-box searches where the errors made by controls increased also. Other scales of SWM had no significant difference between these groups. However the "within errors" had an opposite pattern (compared to between errors) and CD+ADHD patients made lower errors, but the difference did not reach the significance.

During the IED, patients had higher pre-extra and extra dimensional shift errors but no significant difference was observed between groups. CD+ADHD patients had significantly higher total errors compared to ADHD group and controls ($p < 0.05$) and completed fewer stages as well ($p < 0.05$). ADHD group and controls did not have a significant difference.

During the SOC tasks, ADHD group and controls performed equally regarding problems solved in minimal moves but CD+ADHD patients solved a significantly lower number of problems ($p < 0.05$). The number of total moves had a stable pattern within groups: lower number by CD+ADHD toward higher number by controls, which reached the significance in 3 and 5-move problems. Trend of "initial thinking time" for tasks of SOC (as described in table 2) was toward a significantly longer time in 2-move problems by CD+ADHD group, then the time spent by three groups get closer in 3-move problems. There was a slight increase in the time spent by ADHDs and controls in 4-move problems and finally a significantly longer time in 5-move problems was spent by controls and ADHD group ($p < 0.05$).

A significant difference in the subsequent thinking time was just found for 2-move problems between CD+ADHD and ADHD groups ($p < 0.05$).

Iowa gambling task

Significant difference was observed only in the delay time for choosing cards from deck A (bad cards, with the highest amount of loss). CD+ADHD group had the lower delay time

Table 2: Comparison of the CANTAB involving executive functioning between male patients with CD+ADHD, ADHD and the controls.

	CD + ADHD (n=25)	ADHD (n=25)	Control (n=20)	p
Spatial Working Memory				
Between errors	31.44(20.04)	29.20(17.60)	21.25(13.03)	0.140
Within errors	2.96(4.51)	3.45(4.24)	3.45(4.37)	0.909
Double errors	1.44(2.10)	1.80(2.87)	1.40(2.32)	0.845
Total errors	32.69(20.23)	30.85(23.25)	23.25(13.86)	0.174
Strategy utilization	33.64(4.28)	34.00(4.01)	32.10(6.80)	0.458
Intra / Extra dimensional Shift				
Trials of completed stages	77.44(31.01)	81.55(19.07)	75.75(24.61)	0.768
Pre-extra dimensional shift errors	13.00(14.80)	7.75(2.67)	9.95(9.66)	0.265
Extra-dimensional shift errors	13.28(10.69)	9.45(8.90)	7.30(7.34)	0.095
Completed stages	7.72(1.57)	8.65(0.67)	8.25(2.07)	0.018
Total errors (adjusted)	48.88(36.78)	25.40(17.64)	24.25(19.28)	0.007
Total trials (adjusted)	141.44(66.57)	99.05(32.250	90.60(37.48)	0.003
Stockings of Cambridge				
Problems solved in minimal moves	6.68(1.97)	8.30(1.89)	8.30(2.24)	0.012
Total moves				
2 Moves problem	2.06(0.20)	2.05(0.22)	1.95(0.22)	0.267
3 Moves problem	3.62(0.67)	3.32(0.54)	3.00(0.78)	0.012
4 Moves problem	5.68(1.18)	5.32(1.02)	5.26(1.41)	0.457
5 Moves problem	7.93(1.85)	6.74(1.55)	6.03(1.75)	0.002
Mean initial thinking time (ms)				
2 Moves problem	5364.12(7056.79)	1713.70(2155.29)	2084.27(2444.61)	0.035
3 Moves problem	8329.06(8377.14)	6427.82(4920.34)	6445.25(4494.46)	0.512
4 Moves problem	6999.68(4777.21)	7624.97(6805.83)	10402.36(9594.98)	0.264
5 Moves problem	8034.00(6324.58)	10655.93(9419.06)	16770.83(16195.0)	0.035
Mean subsequent thinking time (ms)				
2 Moves problem	4028.68(4375.13)	1014.44(2841.09)	346.52(922.76)	0.237
3 Moves problem	3274.28(4375.12)	5164.43(897.51)	1324.17(4035.41)	0.041
4 Moves problem	5356.74(6278.59)	4189.45(5283.63)	2852.85(2385.09)	0.391
5 Moves problem	2887.67(2876.62)	2488.33(2964.90)	1775.33(2125.33)	0.391

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compared to controls ($p < 0.05$). Healthy controls were more cautious for choosing risky cards than CD+ADHD group. Other results are described in table 3.

Go/ No Go

Results of the Go/No go test are described in table 3. No significant difference was observed in Go trials. Controls had higher scores in most of the No go trials which reached the significance in V_3.

The mean time for errors in response to No go trials was always lower in controls and Post-Hoc analysis showed that it is higher in ADHD patients compared to controls in V_1($p < 0.05$) and higher in CD+ADHD group compared to controls in V_2 ($p < 0.01$).

The mean reaction time to go trials is mostly lower for controls which reaches the significance in V_2 [higher in ADHD group compared to controls ($p < 0.05$)]. The deliverance between CD+ADHD group and controls was significance in No go trial of V_3 ($p=0.08$). ADHD patients had a significantly higher reaction time in Go trials of V_5 compared to controls ($p < 0.01$).

Discussion

The hypothesis was to estimate whether components of EF (as endophenotypes of ADHD and CD) are similar in ADHD

Table 3: Performance on Iowa gambling test and Go/No go task, score or time is given in mean (SD).

		CD + ADHD (n=25)	ADHD (n=25)	Control (n=20)	p
Iowa gambling test					
Main score: (A+B) – (C+D)		-2.36(22.20)	-1.98(20.09)	-5.90(18.01)	0.791
Alternative score : (B+D) – (A+C)		11.12(20.31)	15.50(14.50)	15.00(18.22)	0.709
Delay before selecting from A deck		2812.11(1174.51)	2928.81(1506.25)	4001.77(2085.35)	**0.036**
Delay before selecting from B deck		2268.97(825.13)	1994.19(1356.21)	2403.00(1539.67)	0.852
Delay before selecting from C deck		2827.85(1309.41)	2165.82(785.68)	2857.19(1645.34)	0.175
Delay before selecting from D deck		2493.81(1099.61)	1897.89(844.28)	2436.71(1523.13)	0.219
Go/No Go task					
V1	Go	58.96(8.07)	54.35(11.01)	54.00(12.82)	0.217
	No go	14.20(2.06)	14.45(1.43)	15.20(1.10)	0.120
	Total score	73.16(8.93)	68.80(11.33)	69.20(13.21)	0.345
	Mean reaction time to Go	479.68(101.71)	443.55(70.45)	479.55(87.83)	0.165
	Mean time for errors in No go	171.48(132.63)	237.90(168.44)	106.75(166.23)	**0.034**
V2	Go	52.17(8.46)	52.25(10.08)	49.80(11.40)	0.671
	No go	13.04(1.85)	13.15(2.56)	13.85(1.84)	0.406
	Total score	62.20(8.57)	65.40(10.13)	63.65(11.18)	0.827
	Mean reaction time to Go	375.79(43.49)	391.75(65.03)	343.90(34.09)	0.010
	Mean time for errors in No go	300.96(98.98)	242.40(151.41)	203.45(120.07)	**0.037**
V3	Go	57.96(9.75)	54.90(12.59)	55.00(12.57)	0.603
	No go	11.87(3.21)	13.65(2.91)	14.25(1.58)	**0.013**
	Total score	9.35(1.91)	68.55(12.33)	69.25(12.27)	0.932
	Mean reaction time to Go	386.62(69.93)	383.60(40.49)	385.60(75.16)	0.988
	Mean time for errors in No go	247.04(106.17)	329.40(296.47)	198.45(145.07)	0.110
V4	Go	30.48(6.18)	32.30(5.47)	32.40(6.47)	0.485
	No go	35.20(4.31)	35.35(6.74)	38.10(1.86)	0.089
	Total score	65.68(6.82)	67.65(6.81)	7.50(5.51)	0.052
	Mean reaction time to Go	374.24(35.22)	369.90(47.40)	348.95(29.80)	0.075
	Mean time for errors in No go	267.48(90.65)	259.95(124.67)	193.45(138.56)	0.088
V5	Go	43.72(13.41)	48.10(11.73)	46.35(12.07)	0.499
	No go	12.88(2.24)	13.80(1.61)	13.85(1.14)	0.120
	Total score	56.60(13.66)	61.90(11.81)	60.20(12.22)	0.360
	Mean reaction time to Go	351.64(48.16)	367.55(60.93)	318.70(23.93)	**0.006**
	Mean time for errors in No go	281.92(122.68)	328.05(166.07)	249.95(68.42)	0.087
V6	Go	42.72(13.01)	48.50(11.89)	45.10(13.08)	0.323
	No go	12.64(2.51)	13.05(2.23)	14.20(1.36)	0.052
	Total score	55.36(12.12)	61.55(11.70)	59.30(12.51)	0.227
	Mean reaction time to Go	357.28(59.37)	365.50(700.65)	341.45(57.14)	0.467
	Mean time for errors in No go	287.40(144.90)	314.30(91.41)	221.20(130.10)	0.060

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and CD diagnosed by clinical symptoms. This evaluation was strengthened by adding a group with comorbid ADHD and CD as well as a healthy control group. The current study showed a broad range of deficits in the executive functioning of male adolescents with CD + ADHD compared to healthy controls as well as the matched group with pure ADHD. More to the point, ADHD group showed an intermediate performance compared to CD+ADHD and control groups in several measures.

The study sample had some predictable characteristics. The sample was designated to include groups with matched IQ to decrease the influence of IQ on their performance. The well-known educational problems of children with CD [28,29], is reflected in this sample still. Symptoms of ADHD were expressed in children with ADHD and CD+ADHD (as cognitive problems/Inattention subscale and ADHD index) but CD+ADHD group had higher oppositional behaviors. The components of anger were different between ADHD and CD+ADHD groups which probably resulted in an equal total score of anger in these groups. Lower anger control of ADHD group can be explained by their impulsivity. Executive functioning as a higher-order cognitive processes seem to play an importance role in regulating appropriate affective and behavioral responses when facing high levels of stress [30], and may result in maladaptive expression of anger. Thus the higher instrumental expression of anger in patients with CD + ADHD may be considered as consequence of such deficits.

Children with CD+ADHD had problems in flexibility of attention (fewer completed stages and more errors in IED test). Patients with ADHD did not experience such a problem whereas they did not differ with CD+ADHD group regarding inattentive symptoms. These deficits seem to be stable during time to some extent. Studies show that adult patients with antisocial personality disorder complete fewer stages and have extra-dimensional errors on IED as well [31]. CD+ADHD group showed significant deficit in both extra- and intra-dimensional shift (reflected as higher total errors and less completed trials). This is compatible with the impairments in inhibitory cognitive control reported in adult sample with antisocial behaviors [32]. The result is deficits in shifting attention as well as appropriate response to change of the stimuli.

Problems of spatial planning in children with CD+ADHD were reflected in SOC as more errors, longer initial thinking time for easy problems and shorter time for more complex problems. It seems that in addition to the general deficiency, they give up or answer impulsively when the problems get more complex. However; they spent a longer time for subsequent thinking compared to controls which may be opposed to an impulsive style, thus cognitive problems may be a better explanation for these errors. However the initial and subsequent thinking times are of different nature. The latter is the time when participant is engaged in the process of solving the problem and is likely to be associated to planning abilities rather than impulsivity. This seems to be reflected in fewer numbers of the solved problems and problems solved in minimal moves by CD+ADHD group (even lower than ADHD group). This deficit was dominant in more difficult problems. This is compatible with previous reports about juvenile offenders with CD who had deficits in measures of cognitive ability and visual spatial tests even after adjustment for ADHD [33]. The majority of these results are reported about performance of adult patients with antisocial personality disorder as well [34], who had deficits in planning ability and set shifting.

As described before, results of between and within errors in the study sample had a noticeable pattern, even with no statistical significance. CD+ADHD group had a higher between errors; they revisited boxes which had the token inside. They had lower within errors; they avoided boxes which were found to be empty. Accordingly these children may be more attracted to the previous sources of reward, and may be trying to avoid to be punished again. This model is against the regular understanding of these patients [8]. However this pattern could be biased because of the heterogeneous definition of CD, especial circumstances of a rehabilitation center (thus trying to avoid punishment) or the limitation that we did not evaluate them for psychopathic characteristics.

During the Iowa gambling task all of the participants scored lower in comparison to studies from other countries [35], and earlier reports from our population [36]. Thus this sample did not distinguish between "bad" and "good" decks. The alternative score (previously described) was also lower than a sample of healthy university students [36]. This means that our sample (all the three groups) had a trend to choose the cards with fewer losses (but higher amounts) but CD+ADHD group chose significantly faster from deck A (bad card with higher amount). The consequent punishment did not affect their decision.

Results of the Go/No Go task by CD+ADHD group indicated defi cits of behavioral inhibition. Results of previous reports are mixed, may be due to heterogeneity of the diagnosis, and it is not easy to conclude. While such a defi cit in Go/No Go task was not observed in adults with antisocial behavior [37], another study introduced the symptoms of conduct among the factors related to defi cits in behavioral inhibition [38].

This study had some limitations. CD+ADHD group was experiencing a stressful period of life and their situation might affect their attitude. It was explained that the results of these tests are independent from their legal situation. The three groups were not matched regarding educational level and socio-economic status of the families. These factors though are not assumed as definite confounding factors and we tried to provide better comparison groups by matching their IQ and age.

In conclusion the current study indicated deficits in executive functioning and risk taking behavior of male adolescents with CD and ADHD compared to the matched groups of healthy controls and those with only ADHD symptoms. ADHD group had an intermediate performance compared to CD+ADHD and control groups in several measures. Pattern of these results suggest probability of considering CD+ADHD and ADHD as a continuum in which CD+ADHD is associated with a more severe clinical profile and higher neuropsychiatric deficits. In

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clinical practice, more severe problems of EF in patients with CD and ADHD might be considered and targeted by treatment as most of them influence the behavioral aspects as well like risky behavior.

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