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The executive functions in a sample of Italian adults with ADHD: attention, response inhibition and planning/organization

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Abstract Adults with attention-deficit/hyperactivity disorder (ADHD) show an impaired functioning in multiple cognitive domains: executive functioning (EF), attention, response inhibition, planning and organization, reward and timing. However, the neuropsychological profile of these patients is unclear. Investigations of neuropsychological functioning in a sample of Italian adults with ADHD are currently lacking. The present study aimed at examining neuropsychological performance on tasks measuring executive functioning, attention response inhibition, planning and organization, comparing adults with ADHD (N= 23, mean age 19,7; SD= 3,27) and healthy adults (N= 23, mean age 19,7; SD= 3,27) matched for age and gender. Results showed that adults with ADHD present impaired EF, response inhibition and disorganization/planning. By contrast, they didn't exhibit attention deficits. This study supports the persistence of cognitive impairments in subjects with ADHD also in adulthood. Key words: ADHD; adults with ADHD; executive functions; attention; response inhibition; planning/organization

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neuropsychiatric disorder characterized by inattention, hyperactivity, and impulsivity that is persistent over time (APA, 2013). Although ADHD has been recently reconceptualized as a lifespan disorder, little is known about which neuropsychological deficits perseverate in adults with ADHD. In a recent analysis, Moster and colleagues (2015) examined neuropsychological performance on tasks measuring executive functioning, delay discounting, time estimation and response variability in adults with ADHD compared to healthy adults. Subjects with ADHD showed impaired EF, precisely working memory (WM) and sustained attention, were more sensitive to delay aversion, and exhibited also an increased response variability compared to healthy subjects (Moster et al., 2015). Another meta-analysis highlighted the impairments found in working memory (Alderson, Kasper, Hudec, & Patros, 2013) and long-term memory in a sample of adults with ADHD (Skodzik, Holling, & Pedersen, 2013; Skodzik, Holling, & Pedersen, 2017).

Holst and Thorell (2017) investigated how well neuropsychological measures can discriminate between adults with ADHD and those with other psychiatric disorders. In line with previous studies comparing adults with ADHD and controls (Alderson, Kasper, Hudec, & Patros, 2013; Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010; Fabio & Antonietti, 2012; Halleland, Haavik, & Lundervold, 2012; Liverta Sempio, Fabio, Tiezzi, & Cedro, 2016; Rohlf et al., 2012) they found that adults with ADHD performed more poorly in neuropsychological tests than a psychiatric control group. Similarly, other studies on adults with ADHD show deficits in attention (Fabio & Urso, 2014; Fuermaier et al., 2015; Grane, Endestad, Pinto, & Solbakk, 2014), set-shifting (Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010; Halleland, , Haavik, & Lundervold, 2012; Rohlf et al., 2012), inhibition (Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010; Fuermaier et al., 2015), working memory and autobiographical memory (Fabio & Caprì, 2015; Fuermaier et al., 2015; Lundervold et al., 2015; Rohlf et al., 2012), delay discounting (Marx et al., 2010),

and increased reaction time variability (Feige et al., 2013; Gmehlin et al., 2014; Grane, Endestad, Pinto, & Solbakk, 2014).

In Italian literature on ADHD in adulthood, to our knowledge, no study examined EF. Only four studies examined ADHD prevalence in a sample of Italian students, indicating variable prevalence rates (Bianchini et al., 2013; Frigerio et al., 2009, 2006; Mugnaini et al., 2006). However, the available literature on EF in individuals with ADHD shows slight group differences. These differences can be explained with the use of different assessment tasks and also with the heterogeneous nature of the samples employed (Dobson-Patterson, O'Gorman, Chan, & Shum, 2016; Settineri & Mento, 2014; Mento, 2017). In other words, the studies on ADHD in adulthood didn't provide a complete picture of the cognitive impairments associated with adult ADHD. Thus, a deeper understanding of the EF is needed to derive more precise predictions.

The main aim of the present study was to assess executive functioning in adults with and without ADHD using neuropsychological tests that included measures assessing: attention, response inhibition and planning/organization. To investigate these cognitive processes we employed three tests: Stroop test, Tower of Hanoi and d2 Attention Test. In accordance with previous studies (Fuermaier et al., 2015; Grane, Endestad, Pinto, & Solbakk, 2014) it was hypothesised that the typical and well-documented deficit in attention, inhibition and planning in children with ADHD will perseverate in adults with ADHD.

Methods

Participants

The participants in this study were selected from a sample of 445 students (245 females and 200 males) attending their 5th year of Secondary Education in Sicily, a region of Southern Italy. Students' age ranged from 18 to 21 years (M = 19,7; SD = 3,27) and they were all Italian. All participants gave written informed consent and the head teachers of the schools attended by the participants approved

the study. The American Psychological Association's ethical standards were met in the conduct of this study and the Human Ethics Committee of the Cognitive Science, Psychological, Education and Cultural Studies of University of Messina approved the study protocol.

First phase

Assessment of ADHD symptoms

The Adult ADHD Self-Report Scale v.1.1 (ASRS), published by the World Health Organization (Kessler et al., 2005; Lozano, Carmona, Muñoz-Silva, Fernández-Calderón, Díaz-Batanero, Sanchez-Garcia, 2016), was used to classify subjects into "ADHD" or control groups. The ASRS has high internal consistency (Cronbach's $\alpha = 0.88$) and high intra-class correlation coefficients for subset symptom scores (intra-class correlation coefficients = 0.83; Adler, Spencer, Faraone, Kessler, Howes, Biederman, & Secnik, 2006). The 18-item ASRS was designed to evaluate current manifestation of ADHD symptoms in people aged 18 years or older. Such scale is based on the World Health Organization Composite International Diagnostic Interview, and the questions are consistent with DSM-V criteria. Part-A contains the same 6 items as in the Screener and part-B contains 12 additional questions based on DSM-V criteria. The paper version requires 5 minutes to complete. Subjects are required to use a 5-item Likert scale to indicate the frequency of occurrence of symptoms over the past 6 months (0 = never; 1 = rarely; 2 = sometimes; 3 = often; 5 = very often). For each subject, the total score was obtained summing the scores of hyperactivity subscale and inattention subscale (maximum total score: 72; maximum score in inattention subscale: 36 and maximum score in hyperactivity subscale: 36).

Second phase

Students who exceeded the cut-off scores in ASRS moved on to the second phase for a clinical diagnosis carried out by a specialized psychologist during individual interviews. The psychologist conducted interviews to exclude ADHD-like

symptoms such as bipolar disorders (early onset bipolar disorder), depression, oppositional defiant disorder and dependence. He also examined if the symptoms causing impairment were reported in two or more settings, the onset age of the disorder and the use of medication. After the individual clinical assessment, all participants who followed a medication regime or that had a psychopathology associated with anxiety, depression, psychosis or mental retardation were excluded from the study.

The final sample included: 23 students (21 males and 2 females) with ADHD combined presentation (ADHD-C) and 23 students as a typically developing control group (TD). The mean age was 19,7 years for each group. The characteristics of the final sample were summarised in Table 1.

Table 1. Mean (M) and standard deviations (SD) of the ASR for ADHD and TD group and characteristics of groups.

	ADHD GROUP M (SD)	TD GROUP M (SD)
n. boys/girls	21/2	21/2
Age	19.7 (3.27)	19.3 (2.58)
ASRS		
Total	44 (3.22)	4.1 (1.3)
Inattentive	10 (3.22)	1.2 (1.4)
Hyperactive/impulsive	34 (3.22)	3.9 (1.1)

The TD group was recruited from the same classroom of each of the subjects with ADHD and they were matched by age and gender. Moreover, the control participants met no criteria identified by ASRS and were not diagnosed as affected by behavioural, emotional and/or relational problems by the specialized psychologists.

Neuropsychological measurements

The neuropsychological test battery included measures of: attention, response inhibition and planning/organization. The tests were: Stroop Test, Tower of Hanoi and d2 Attention Test. All the tests were administered via computer using the software Presentations.

Stroop Test

The Stroop Test, also known as the color-word naming test, is used to measure the ability to shift attention and inhibit interfering information (MacLeod, 1991). In the classic version, subjects are shown words printed in a color different than that expressed by the word's meaning. The Stroop effect occurs when the printed color naming words are incongruent with the colored ink (e.g. the word green printed in yellow).In the current study, the Stroop Test was administered via an IBM PC-compatible computer. The stimuli consisted of 10 words printed in four colored inks (blue, red, yellow, and green) and formatted in 45-point Arial font. Two types of stimulus words were used: words written in the color congruent with the color expressed by the word's meaning and words written in a color incongruent with the color expressed by the word's meaning.Participants were required to rapidly name a list of color words (blue, red, green or yellow) in which the color of the text can be incongruent or congruent with the word itself (Stroop, 1935). They were instructed to respond as quickly as possible to the appearance of the congruent stimulus by pressing the number 1 key and the number 2 key in response to the incongruent stimulus. Participants were seated facing a 19" monitor that was approximately 60 cm away from them. The inter-stimulus interval was 1s and the stimulus duration was 75s. The following parameters were calculated: number of correct responses and the execution time of the incongruent task.

Tower of Hanoi

The Tower of Hanoi is a mathematical game or puzzle, created by Edouard Lucas in 1883. It consists of three pegs, and a number of disks of different sizes. The

goal of the game is to move the entire stack to another rod, by following three rules: only one disk can be moved at a time; the disk can only be moved if it is the uppermost disk on a stack; no disk may be placed on top of a smaller disk.

In this study, subjects were presented with 10 problems via a computer, in which they viewed the target arrangement (model) and matched it by rearranging different colored disks on 3, 4, or 5 pegs of different sizes. They were asked to move the disks as in the model in the fewest possible moves, according to the rules described above, and starting from a default position. The initial starting position was displayed on the left, and the goal position was displayed on the right. Participants used the computer mouse to move the disks and had 2 minutes to solve each problem. Only if they completed the first task, they could solve the next one. The number of moves to resolve the problem, the number of violations of the rules and the frequency of the correct solution to solve the problem were calculated.

The d2 Attention Test

The d2 Attention Test (Brickenkamp & Zillmer, 1998) is designed to measure processing speed, rule compliance, and quality of performance in response to the discrimination of similar visual stimuli. This test consists of 14 lines, each containing 47 characters, for a total of 658 stimuli. The stimuli were the letter “p” and “d” with one to four dashes, arranged either individually or in pairs above and below the letter. The subject was asked to mark, as quickly as possible, the letter “d” printed with two dashes that could be either above or below the letter. Total administration time was 6 minutes. According to the d2 Test manual (Brickenkamp & Zillmer, 1998), the following parameters were measured: the total number of stimuli processed, as a measure of processing speed; the number of false alarms (errors of commission: marked d’s with fewer or more than 2 dashes or p’s) as a measure of accuracy. In the present study, the d2 Test was administered for three consecutive times in order to assess the sustained attention.

Procedure

The participants were tested in a quiet area of the school. The d2 Attention Test was administered in a group format, whereas the Stroop Test and the Tower of Hanoi were administered individually. The order of test administration was random across the different trials. ADHD group and the control group were tested separately. Total administration time was 40 minutes approximately. All subjects were tested in the morning from 9 to 11 a.m.

Statistical analyses

The data were analyzed using SPSS 20.0 for Mac. The descriptive statistics of the dependent variables were tabulated and examined. The alpha-level was set to .05 for all statistical tests. In case of significant effects, the effect size of the test was reported. The effect sizes were computed and categorized according to Cohen (1988).

Results

Table 2 and 3 show the means and standard deviations of neuropsychological measures for the tests used in this study. As expected, the ADHD-C group obtained significantly lower scores in the "incongruent condition" of Stroop Test, compared to the control group, $t(45) = 2.885$, $p = .05$. There was a significant effect also for the "time of execution" parameter, $t(45) = 2.324$, $p = .05$.

Table 2. Mean (M) and standard deviations (SD) of the Stroop Test and Tower of Hanoi for ADHD and TD group.

TESTS	ADHD GROUP M (SD)	TD GROUP M (SD)	t	df	P-values	Cohen's *d*
STROOP TEST						
Number of RC	22.692 (2.136)	23.846 (0.554)	2.885	45	.05	.78
Execution Time	36.692 (12.181)	33.076 (7.262)	2.324	45	.05	.78
TOWER OF HANOI						
3 disks						
Moves	16.692 (8.199)	11.076 (4.517)	2.163	43	.05	.78
Violations	2.692 (1.843)	1.230 (1.786)	2.053	43	.05	.78
Frequency	21/23	23/23				
4 disks						
Moves	30.909 (15.280)	22.538 (4.665)	1.881	35	.05	.78
Violations	2.000 (3.741)	0.384 (0.650)	1.536	35	.139	.40
Frequency	17/21	19/23				
5 disks						
Moves	58.333 (7.984)	43.727 (9.768)		5	.002	.60
Violations	2.444 (1.740)	0.727 (1.420)		5	.026	.30
Frequency	1/17	5/19				

Table 3. Mean (M) and standard deviations (SD) of the d2 Attention Test for ADHD and TD group.

D2 ATTENTION TEST	ADHD GROUP M (SD)	TD GROUP M (SD)	F	df	P-values
First phase					
Processing speed	30.615 (6.331)	30.923 (7.111)	0.683	1. 45	.442
Accuracy	2.384 (3.014)	3.000 (4.618)	0.219	1. 45	.602
Second phase					
Processing speed	35.846 (8.820)	38.153 (6.348)	0.922	1. 45	.442
Accuracy	3.076 (2.782)	2.307 (2.250)	0.35	1. 45	.602
Third phase					
Processing speed	36.230 (10.607)	39.307 (4.190)	0.81	1. 45	.442
Accuracy	2.923 (3.040)	1.769 (1.640)	0.99	1. 45	.602

With reference to the Tower of Hanoi, in the problem with three disks, since 2 of 23 subjects with ADHD didn't solve the problem, data refers to 21 of 23 subjects with ADHD and to 23 TD subjects. The ADHD group exhibited a worse performance compared to TD group, showing higher scores in the "number of moves" parameter, $t(43) = 2.163$, $p = .05$ and in the "violation of the rule" parameter, $t(43) = 2.053$, $p = .05$. In the problem with four disks, 17 of 21 subjects of the ADHD group and 19 of 23 of the TD group correctly solved the task. The ADHD group significantly obtained higher scores in the "number of moves" parameter than control subjects, $t(35) = 1.881$, $p = .05$, but in the "violations of the rule" parameter there was no significant effect, $t(35) = 1,536$, $p = .139$. In the problem with five disks, 16 subjects with ADHD and 14 TD

subjects didn't solve the problem, for these reasons no statistic was computed. As regards to the d2 Attention Test, ANOVA 2 (groups: ADHD group vs TD groups) x 3 (phases) was carried out. The parameters were: processing speed and accuracy. Both factors (groups and phases) showed no significant effects with reference to the "processing speed" parameter and "false alarm" parameter. The ADHD group obtained higher scores compared to the TD group, although it was not statistically significant.

Discussion

The main aim of the current study was to assess executive functioning in adults with and without ADHD using neuropsychological tests related to: attention, response inhibition and planning/organization. ADHD group showed impaired performance on response inhibition and planning/disorganization tasks. In the Tower of Hanoi, the differences between the groups were statistically significant from the moment the first simple problem was presented. These findings indicated that subjects with ADHD have more difficulties to represent the task mentally and to select the strategy of solution (Brown, 2013; Fabio, 2017; Fabio, Castriciano, & Rondanini, 2015). Results also showed that adults with ADHD exhibited impaired performance in the Stroop Test. This result is consistent with previous research (Fabio & Urso, 2014; Fuermaier, Tucha, Koerts, Aschenbrenner, Weisbrod, Lange et al., 2014; Fuermaier et al., 2015; Salomone, Fleming, Bramham, O'Connell, & Robertson, 2016), confirming that adults with ADHD are less efficient in the modulation of attention, and in the selection of the most relevant information. In addition, the results revealed no significant effects in the d2 Attention Test. Although, the ADHD group was shown to perform more poorly compared with TD group, no significant effects were found.Overall, as expected, patients with ADHD showed impaired EF, especially, response inhibition and disorganization/planning. These results are in line with previous studies comparing adults with ADHD and healthy subjects (Alderson, Kasper, Hudec, & Patros, 2013; Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010; Halleland, Haavik, & Lundervold, 2012; Rohlf et al., 2012). Hence, our findings add support to the knowledge that impaired inhibition and planning are core

deficits also in adults with ADHD. Contrary to expectations, we did not find any difference related to attention. This result does not confirm previous studies in which an attention deficit was reported (Woods, Lovejoy, & Ball, 2002; Hervey, Epstein, & Curry, 2004; Schoechlin & Engel, 2005; Moster et al., 2015; Dobson-Patterson et al., 2016). The reasons for this discrepancy are unclear. We used the d2 test to measure attention, while in previous research other tools were employed, such as Sustained Attention to Response Task (SART) and Trail Makinig Task (Moster et al., 2016; Dobson-Patterson, O'Gorman, Chan, & Shum, 2016). Salomone, Fleming, Bramham, O'Connell, and Robertson (2016) also used the SART, in line with our results they found that the performance of adults with ADHD on selective attention tasks show no difference from control participants' performance. In another study, the Letter Cancellation Test (LCT) was used to evaluate selective attention. This test is similar to the d2 test, it consists of rows of letters interspersed at random with a designated target letter. Subject searches the target from left to right, row by row, from top to bottom. Performance was scored in terms of number of errors and number of lines completed within the allocated 120 seconds. Also in that study an attention deficit was found, in contrast to the outcome of the current research. Probably, our results could be due to the simplicity of the d2 test as this test may be less sensitive in measuring the specific deficit of attention in adults. This study had some limitations, we only considered the ADHD-C presentation.

Conclusion

Future research should focus on the different presentations of ADHD in adulthood and may obtain a better understanding of cognitive functioning of adults with ADHD in terms of the underlying differences between the three presentations of ADHD, id et inattentive, hyperactive and combined presentations. In conclusion, our results suggest that people with ADHD perseverate to show executive deficit, in particular in inhibition and planning/organization abilities. The current study contributes to the field's understanding of executive functioning in adults with ADHD and supports the notion of the persistence of cognitive impairments in subjects with ADHD also in adulthood.

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