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## Attention, problem solving and decision making in adult subjects with ADHD

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### ABSTRACT

*Objectives:* Although attention-deficit/hyperactivity disorder (ADHD) is clearly associated with executive dysfunctions, the neuropsychological profile of adults with ADHD is unclear.

The present study aimed at examining neuropsychological performance on tasks measuring attention, problem solving and decision making in young adults with ADHD.

*Methods:* 12 young adults with ADHD (Mean age 18.33; SD= 11.48) and 12 healthy young adults (Mean age 18.41; SD= 18.70) matched for age and gender, performed the following neuropsychological test battery: Stroop Test, Tower of Hanoi and Gambling Task. All the tests were administered via computer using the software Presentations.

*Results:* Results showed that adults with ADHD exhibit deficits in attention, problem solving and decision making. These findings warrant further examination of neuropsychological profile in adults with ADHD to improve the understanding of underlying neurocognitive mechanisms.

*Conclusions:* This study suggests that young adults with ADHD show a considerable impairment in attention, problem solving and decision making. The present study contributes to understanding the neuropsychological picture of young adults with ADHD.

**Keywords:** *ADHD; Adults with ADHD; Attention; Problem solving; Decision making*

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## **Introduction**

Attention Deficit Hyperactivity Disorder (ADHD) represents one of the most common neuropsychiatric disorders in childhood (Thomas, Sanders, Doust, Beller, & Glasziou, 2015). It persists into adolescence and adulthood in 30% to 60% of cases (Biederman et al, 2006). Worldwide incidence is between 5% and 15% of the school-aged population (Asherson, Buitelaar, Faraone, & Rohde, 2016). The disorder is characterized by the following symptoms: inattention, hyperactivity and impulsivity. Decades of research have revealed that ADHD is associated with several executive dysfunctions such as: set shifting, problem solving, working memory (WM), inhibition, autobiographical memory, motivational processes, decision making and reinforcement learning (Antonietti, Monnier, Gatti, & Fabio, 2010; Fabio, 2017; Fabio & Capri, 2015; 2017; Fabio, Capri, Mohammadhasani, Gangemi, Gagliano & Martino, 2018; Fabio, Piran, & Antonietti, 2005; Mohammadhasani, Fabio, Fardanesh, & Hatami, 2015; Martino, Capri, Castriciano, & Fabio, 2017; Mohammadhasani, Fardanesh, Hatami, Mozayani, Fabio, 2018; Stark et al., 2011)

Although executive impairments are well documented in children with ADHD and this disorder has been recently reconceptualized as a lifespan disorder, little is known about neuropsychological profile of adults with ADHD. Previous studies indicated that, in comparison to healthy adults, adult subjects with ADHD showed deficiencies of various functions, such as: attention, WM, concept formation, impulsivity, inhibition, shifting, delay discounting and increased reaction time variability (Alderson, Kasper, Hudec, & Patros, 2013; Boonstra, Kooij, Oosterlaan, Sergeant, & Buitelaar, 2010; Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Fabio & Antonietti, 2012; Fabio, Castriciano, & Rondanini, 2015; Fabio & Urso, 2014; Feige et al., 2013; Fuermaier et al., 2015; Gmehlin et al., 2014; Grane, Endestad, Pinto, & Solbakk, 2014; Halleland, Haavik, & Lundervold, 2012; Lundervold et al., 2015; Johnson et al., 2001; Liverta Sempio, Fabio, Tiezzi, & Cedro, 2016; Marx et al., 2010; Rohlf et al., 2012; Tucha et al., 2006).

Holst and Thorell (2017) investigated how neuropsychological measures can discriminate between adults with ADHD and those with other psychiatric disorders. They found that adults with ADHD performed more poorly in neuropsychological tests than the control group. Mäntylä, Still, Gullberg and Del Missier (2012) examined decision-making competence in adults with and without ADHD, using the Adult Decision-Making Competence (A-DMC) battery, and two affective decision tasks (the Balloon Analog Risk Task and the Iowa Gambling Task). The results indicated that ADHD was associated with impaired decision making in all tasks. A meta-analysis of decision making and attention in adults with ADHD studied 59 studies, demonstrating the presence of DM deficits in adults with ADHD, which are of similar magnitude as attention deficits (Mowinckel et al., 2015).

Despite some cognitive processes have been studied, problem-solving abilities of adults with ADHD have not been examined in detail. In Italian literature on ADHD in adulthood, the existing studies didn't provide a complete picture of the cognitive impairments associated with ADHD in adulthood.

On the basis of these theoretical considerations, the present study examined attention, problem solving and decision making in adults with and without ADHD. To investigate these cognitive processes we employed three tests: Stroop test, Tower of Hanoi and Iowa Gambling Task. It was hypothesized that the well-documented deficits in attention, problem solving and decision making in children with ADHD will be displayed also in adults with ADHD.

## Methods

### *Participants*

The participants in the present study were selected from a sample of 130 students (80 females and 50 males) attending their 5th year of Secondary Education in Lombardy, a region of Northern Italy. Students' age ranged from 18 to 21 years ( $M = 18,7$ ;  $SD = 3,27$ ) 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. To select students with ADHD symptoms, two phases were followed.

*First phase.* 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). In this study, the ASRS was compiled by teachers and students.

*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: 12 students (12 males and 0 females) with ADHD combined presentation (ADHD-C) and 12 students as a healthy control group (HC). The mean age was 18 years for each group. The characteristics of the final sample were summarised in Table 1.

	ADHD GROUP M (SD)	CONTROL GROUP M (SD)
n. boys/girls	12/0	12/0
Age	18.3 (11.48)	18.4 (18.70)
ASRS		
Total	39.33 (8.61)	5.9 (6.11)
Inattentive	21.50 (6.07)	1.2 (3.80)
Hyperactive	17.83 (4.23)	4.7 (2.47)

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

The HC 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, problem solving and decision making. The tests were: Stroop Test, Tower of Hanoi and Gambling Task. All the tests were administered via computer using the software Presentations.

*Stroop Test (Stroop, 1935).* 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 (Shallice, 1982)*. 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.

*Iowa Gambling Task (IGT) (Bechara et al., 1994)*. The IGT allows to assess the decision making in a laboratory setting. Participants were given €1500 to start, and are told to maximize profit by selecting cards from among four decks of cards varying in their amounts of monetary reward and punishment, but they didn't know the monetary scores. To enhance motivation, we paid participants who had positive net earnings at the end of the task that amount at the end of the study. The decks were divided into two types: desks A and B called "disadvantageous", because the selection from these decks is deemed risky, while Decks C and D were "advantageous", because the selection allows to win (Bechara et al. 1994).

### Procedures

The participants were tested in a quiet area of the school. The Gambling Task 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 22.0 for Windows. 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). Data were analyzed using repeated-measures ANOVA with the independent variable (types of group: ADHD groups vs control group) and dependent variables (parameters of the tests used in this study).

### Results

Table 2 shows the means and standard deviations of neuropsychological measures for the tests used in this study. With reference to IGT, the dependent variables were: the total score and the execution time. The first variable showed significant effects,  $F(1, 22) = 16.82$ ;  $p < .01$   $d = 0.92$ ; the ADHD group has a worse performance compared to the healthy controls. We found no significant effect in the second variable,  $F(1, 22)=0.17$ ,  $p=0.7$ .

Parameters	ADHD group M (DS)	Control group M (DS)	d.f.	F	p
<i>Gambling Task</i>					
Scores	1391.66 (440.47)	2087.50 (389.12)	1, 22	16.82	0.00
Execution time in seconds	563.66 (101.58)	584.25 (138.05)	1, 22	0.17	0.68
<i>Tower of Hanoi</i>					
Moves	88.91 (28.00)	42.00 (5.34)	1, 22	32.50	0.00
<i>Stroop Test</i>					
Total	45.58 (3.14)	50.16 (0.83)	1, 22	23.78	0.00
Color	21.25 (1.60)	23.58 (0.90)	1, 22	19.33	0.00
Position	24.33 (2.60)	26.50 (0.67)	1, 22	7.77	0.01

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

As regards to the Tower of Hanoi, the factor “number of moves” showed significant effects,  $F(1, 22)=23.78$ ,  $p<0.01$ . This means that the ADHD groups had a poorer performance than the HC group.

We also found significant effects in the Stroop Test,  $F(1, 22)= 19.33$ ,  $p<0.01$ ;  $F(1, 22)= 7.77$   $p=0.01$ . Again, the ADHD show a worse performance compared to the control subjects.

### **Discussion**

The main aim of the current study was to examine attention, problem solving and decision making in adults with and without ADHD using neuropsychological tests. As expected, results revealed that the ADHD group displayed marked deficits in all tasks. 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).

These results are 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), demonstrating that adults with ADHD are less efficient in the modulation of attention, and in the selection of the most relevant information.

Contrary to expectations, we did not find any difference related to “execution time” parameter of IGT. This could be explained by saying that, in this study, only laboratory measures were performed. Therefore, the results of ADHD participants on IGT may not accurately represent symptoms and problems associated with ADHD as they occur in natural settings such as decision making in a workplace.

The present results must be viewed in the context of some limitations. First, the sample sizes were small (12 adults with ADHD and 12 healthy control participants). A second restriction of the study is that we only considered the ADHD-C presentation. Future studies should aim to replicate results in a larger sample, considering the different presentations of ADHD in adulthood.

In conclusion, our results suggest that adults with ADHD show a considerable impairment in attention, problem solving and decision making. The present study contributes to understanding the neuropsychological picture of adults with ADHD.

### ***Compliance with Ethical Standards***

The authors declare no conflict of interest and no source of funding for the present research. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all parents of participants included in the study.

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