



#### INDICE:

##### 1. Dalle banche dati bibliografiche

pag. 2

##### 2. Documenti

Casagrande M, Martella D, Ruggiero MC, Maccari L, Paloscia C,  
Rosa C, Pasini A. **Assessing attentional systems in children with  
Attention Deficit Hyperactivity Disorder.**

*Arch Clin Neuropsychol* 2012;27(1):30-44.

pag. 16

## **BIBLIOGRAFIA ADHD MAGGIO 2012**

Arq Neuro-Psiquiatr. 2012;70:91-96.

### **PERFORMANCE PATTERNS IN CONNERS' CPT AMONG CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER AND DYSLEXIA.**

***Miranda MC, Barbosa T, Muszkat M, et al.***

This study investigated the performance of children with attention deficit hyperactivity disorder (ADHD) and dyslexia using Conners' Continuous Performance Test (CCPT). The clinical groups were composed of 52 children with ADHD and 32 children with dyslexia. Performance in the CCPT was evaluated using ANCOVA to compare the clinical groups with the normative Brazilian sample. The ADHD group performed worse than the normative sample in almost all of the measurements, except for reaction time and response style. The dyslexia group scored higher on commissions, variability, perseverations and inconsistency in the reaction time over the six time blocks (Hit SE Block Change) than the children in the normative Brazilian sample. The ADHD and dyslexia groups differed in omission measurements, Hit RT SE, variability, perseverations, Hit RT Interstimulus Intervals (ISI) Change and Hit SE ISI Change. We thus found that the dyslexia group had specific deficit patterns, with greater response to non-target stimuli, greater perseveration and response variability, and difficulties in hit reaction time as the test progressed.

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Per la ricerca degli articoli pubblicati nella letteratura scientifica nel mese in esame sono state consultate le banche dati Medline, Embase, PsycINFO e PsycArticle utilizzando le seguenti parole chiave (o i loro sinonimi): 'Attention deficit disorder', 'Attention deficit hyperactivity disorder', 'Infant', 'Child', 'Adolescent', 'Human'. Sono qui riportate le referenze considerate rilevanti e pertinenti.

Behavioral Sciences & the Law. 2012 Mar;30:154-66.

**PREVALENCE OF ADHD AND ITS SUBTYPES IN MALE AND FEMALE ADULT PRISON INMATES.**

**Cahill BS, Coolidge FL, Segal DL, et al.**

There are few published studies of attention-deficit/hyperactivity disorder (ADHD) in adult inmates, and even fewer studies that have considered ADHD in adult inmates by gender. The present study examined the prevalence of ADHD, its subtypes, and associated psychological and neuropsychological comorbidity as a function of gender in a sample of 3,962 inmates (3,439 men and 523 women; mean age = 33.6 years, range 17–73) who had completed the 250-item, self-report, Diagnostic and Statistical Manual of Mental Disorders, 4th edition (Text Revision) (DSM-IV-TR)-aligned Coolidge Correctional Inventory (CCI). The overall ADHD prevalence rate found was 10.5%, which is substantially higher than the rate among adults in the general population (2–5%). The female inmate ADHD prevalence rate (15.1%) was higher than the male inmate ADHD rate (9.8%), consistent with some previous studies. The most prevalent ADHD subtype for both genders was the hyperactive-impulsive subtype. The combined and inattentive ADHD subtypes had higher levels of comorbid psychopathology than the hyperactive-impulsive ADHD subtype. As the presence of ADHD and associated gender differentials may impact the success of rehabilitation and educative programs with inmates, the assessment of ADHD and comorbid psychopathology should be a priority in initial inmate screening and evaluation.

Biol Psychol. 2012 Mar;89:606-08.

**CAFFEINE EFFECTS ON RESTING-STATE ELECTRODERMAL LEVELS IN AD/HD SUGGEST AN ANOMALOUS AROUSAL MECHANISM.**

**Barry RJ, Clarke AR, McCarthy R, et al.**

The effect of a single oral dose of caffeine was examined in a randomised double-blind placebo-controlled repeated-measures cross-over study. Eighteen children with AD/HD, aged between 8 and 13 years, were individually age- and gender-matched with a control group. All children participated in two sessions, one week apart. Skin conductance level (SCL) from a 3 min eyes-closed epoch, commencing 30 min after ingestion of caffeine or placebo, was examined. Across conditions, mean SCL was lower in the AD/HD group than controls, confirming hypoarousal in AD/HD. Caffeine produced an increase in SCL, and this increase did not differ between the groups. However, arousal increases were dose-dependent in controls, but not in AD/HD. Rather, caffeine-induced arousal increases in the AD/HD group were positively related to their hyperactivity/impulsivity levels. This suggests an anomalous arousal mechanism in AD/HD functionally related to impairment in one symptom dimension.

Brain & Development. 2012 May;34:354-59.

**EXECUTIVE FUNCTION IN CHILDREN WITH PERVASIVE DEVELOPMENTAL DISORDER AND ATTENTION-DEFICIT/HYPERACTIVITY DISORDER ASSESSED BY THE KEIO VERSION OF THE WISCONSIN CARD SORTING TEST.**

**Kado Y, Sanada S, Yanagihara M, et al.**

The Wisconsin card sorting test (WCST) comprehensively examines executive function (EF). The Keio version of the WCST (KWCST) uses fewer cards and presents them in two steps, separated by a short pause during which an instruction is given. Being of short duration, this test is suitable for children with pervasive developmental disorder (PDD) and attention-deficit/hyperactivity disorder (AD/HD), yet few studies have examined the performance of children with such developmental disorders in the second step of a two-step test such as the KWCST. Using the KWCST, this study compares EF in children with PDD (n = 52), or AD/HD (n = 46) to that in typically developing (TD) children (n = 52). Scores for the six indices of this test, including numbers of response cards until the first category achieved (NUCA), total errors (TE), and non-perseverative errors of Nelson (NPEN), were analyzed using ANOVA. Compared to the TD group, scores in the PDD and/or AD/HD groups were significantly lower for all indices except NUCA and NPEN for the first step, and lower for all indices except NUCA for the second step. Moreover, significantly fewer improvements in TE were seen in the PDD group, and significantly fewer improvements in NPEN were seen in the AD/HD group, compared with TD. This study suggests that both PDD and AD/HD make it

difficult for children to utilize their experience in the first step and to effectively apply the instruction given before the second step. It also suggests that the two-step nature of the KWCST is clinically important.

Children and Youth Services Review. 2012 Apr;34:826-33.

**A COMPARATIVE REVIEW OF “HOW TO” BOOKS FOR PARENTS OF ADHD CHILDREN AND “HOW TO” BOOKS FOR PARENTS OF TYPICAL CHILDREN.**

**Pajo B, Stuart PH.**

Although an increasing number of children are diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and take medications to control their behaviors, a well-publicized controversy persists about whether ADHD refers to a common neurobehavioral disorder of childhood or to various medicalized temperamental, educational, and cultural differences and difficulties of children. Moreover, behaviors indicative of ADHD are commonly found among all children—although with different frequencies. This paper aims to identify and compare the type of information provided to parents of ADHD and non-ADHD diagnosed children through readily available self-help books. Searches using popular online bookstores were conducted to rank and select the ten most popular self-help books for parents of ADHD diagnosed children and those of typical children, from which relevant information was systematically extracted. We

conclude that the information provided for these two sets of parents was substantially different, if not opposites, but children's behaviors were similarly portrayed.

Clin Neuropharmacol. 2012 Mar;35:81-85.

**EFFECT OF 12-WEEK ADMINISTRATION OF 20-MG LONG-ACTING METHYLPHENIDATE ON GLU/CR, NAA/CR, CHO/CR, AND ML/CR RATIOS IN THE PREFRONTAL CORTICES OF SCHOOL-AGE CHILDREN IN INDONESIA: A STUDY USING <sup>1</sup>H MAGNETIC RESONANCE SPECTROSCOPY (MRS).**

**Wiguna T, Guerrero APS, Wibisono S, et al.**

**Objectives:** Recent studies on the neurobiology of attention-deficit/hyperactivity disorder (ADHD) have suggested that there is dysregulation of dopamine-mediated neurotransmission, particularly in the prefrontal cortex and basal ganglia, and that treatment with methylphenidate reverses this dysregulation. Using methodology similar to previous studies involving putative markers of brain functioning, we used <sup>1</sup>H magnetic resonance spectroscopy to study the effect of 12-week treatment with daily 20-mg long-acting methylphenidate on the glutamate/creatine, N-acetyl-aspartate/creatine, choline/creatine, and myoinositol/creatine ratios in the prefrontal cortices of medication-naïve children with ADHD.

**Method:** This was a prospective study, using a pretest and posttest design, on a single group of 21 children (mean age, 8.52 years; 17 males and 4 females) with a diagnosis of ADHD. A low time echo (TE) magnetic resonance spectroscopic scans sampled voxels of interest (1.5 × 1.5 × 2.0) from both the right and left prefrontal cortices.

**Results:** After treatment, the N-acetyl-aspartate/creatine ratio increased 18.8% in the right prefrontal cortex (P = 0.001) and 10% in the left prefrontal cortex (P = 0.007); the glutamate/creatine ratio decreased 15% in the right prefrontal cortex (P = 0.005) and 14.1% in the left prefrontal cortex (P = 0.005); the choline/creatine ratio decreased 12.4% in the right prefrontal cortex (P = 0.037) and 16% in the left prefrontal cortex (P = 0.006); and the myoinositol/creatine ratio decreased 14.7% in the left prefrontal cortex (P = 0.011) and 7.7% in the right prefrontal cortex (P = 0.129).

**CONCLUSION:** Notwithstanding the limitations of this pilot study, we found, after stimulant treatment, significant neurochemical changes (thought to reflect functional improvement and improved neuroplasticity) in the prefrontal cortices of children with ADHD.

Contemporary Educational Psychology. 2012 Apr;37:91-105.

**THE ROLE OF PERSONAL BEST (PB) GOALS IN THE ACHIEVEMENT AND BEHAVIORAL ENGAGEMENT OF STUDENTS WITH ADHD AND STUDENTS WITHOUT ADHD.**

**Martin AJ.**

In the context of competitive classroom settings and relativistic assessment schedules, some groups of students may particularly benefit from an emphasis on personal progress and personal growth approaches to their academic development. Building on recent promising results from general samples of high school students (undifferentiated by academically at-risk sub-groups within them) and dominant models of attention and executive functioning, the present study examines the potential of personal best (PB) goals for students with attention-deficit/hyperactivity disorder (ADHD). The study focuses on N = 87 students with ADHD and N = 3374 non-ADHD peers from the same schools and year levels—in addition to a supplementary analysis of a randomly drawn non-ADHD sub-sample of N = 87 and a second supplementary analysis controlling for achievement. Multi-group multivariate path analyses demonstrated (a) significant and positive associations between PB goals and academic outcomes (achievement and behavioral engagement) for students with ADHD, (b) similar positive effects for non-ADHD students (N = 3374), (d) replicated results with the randomly drawn non-ADHD sub-sample (N = 87), (e) similar findings when controlling for achievement, and (f) absolute parameter estimates that trended larger for students with ADHD than non-ADHD students. These findings indicate that the positive role of PB goals may generalize across diverse student groups and that there appears to be merit in broadly promoting PB goals amongst ADHD (and, potentially, other academically at-risk students) and non-ADHD students alike.

Contemporary Educational Psychology. 2012 Apr;37:106-12.

**ATTENTIONAL CUEING IN MATH WORD PROBLEMS FOR GIRLS AT-RISK FOR ADHD AND THEIR PEERS IN GENERAL EDUCATION SETTINGS.**

**Kercood S, Zentall SS, Vinh M, et al.**

The purpose of this theoretically-based study was to examine the effects of yellow-highlighting 'relevant' words and units within math word problems. Initial differences were documented between 10 girls at-risk for ADHD and 10 comparisons on the performance of group and individual assessments of math computations and word problems, as had previously been reported for boys. To address these deficits (faster speed and lower accuracy) for the at-risk group, these fourth-grade girls were randomly assigned word problems under two experimental conditions (highlight vs. nohighlight) within a counterbalanced condition- and form-order design. Intervention gains were (a) slower rate of performance, (b) decreased off-task behavior, and (c) improved problem solving performance, differentially for girls at-risk for ADHD when their materials were first presented with highlighting—the effects of which carried over to a nonhighlight condition. The theoretical, practical, and future research implications of this study are addressed.

Eur Child Adolesc Psychiatry. 2012;1-12.

**Within-subject variability during spatial working memory in children with ADHD: an event-related potentials study.**

**Myatchin I, Lemiere J, Danckaerts M, et al.**

Working memory (WM) dysfunction and increased within-subject variability are known issues in attention deficit/hyperactivity disorder (ADHD) patients. Little is known about the electrophysiological characteristics of this variability. We evaluated behavioral and electrophysiological within-subject variability taking developmental aspects into account in a group of ADHD patients. Multichannel (n = 31) event-related potentials (ERP) were measured during a visuo-spatial backmatching task; 44 children (8-16 years old) were tested: 22 children with ADHD, combined (n = 17) and inattentive (n = 5) type, and 22 age- and intelligence-matched control children. One-backmatching (BM1) and two-backmatching (BM2) tasks were performed. Classical behavioral parameters and target and nontarget ERP were compared between groups. In addition, motor response variability and ERP amplitude variability were studied. Age-related changes in both motor response and ERP amplitude variability were analyzed in each group. Attention deficit/hyperactivity disorder children made more commission errors, which was more pronounced in the

difficult (BM2) task. No difference between groups was found in ERP amplitude and in motor response variability. However, ADHD patients had higher ERP amplitude variability, which was again more pronounced in the difficult WM task. A delayed maturation of amplitude variability was seen in ADHD patients with a slower than in controls decrease in variability with age. This amplitude variability was correlated with the number of commissions, but in an opposite way for ADHD and control children. Our findings indicate an impaired visuo-spatial WM processing in ADHD children with greater ERP amplitude variability compared to controls. Our results also support the view of a delayed cortical development of visuo-spatial WM circuits in this disorder.

Journal of Abnormal Child Psychology: An official publication of the International Society for Research in Child and Adolescent Psychopathology. 2012 May;40:527-42.

**AGGRESSION AMONG CHILDREN WITH ADHD, ANXIETY, OR CO-OCCURRING SYMPTOMS: COMPETING EXACERBATION AND ATTENUATION HYPOTHESES.**

**Becker SP, Luebke AM, Stoppelbein L, et al.**

Competing hypotheses for explaining the role of anxiety in the relation between attention-deficit/hyperactivity disorder (ADHD) symptoms and childhood aggression were evaluated. Two studies tested whether anxiety exacerbated, attenuated, or had no effect on the relation between ADHD and aggression subtypes among psychiatrically hospitalized children. In Study 1 (N = 99), children who scored above clinical cut-off levels for anxiety only, ADHD only, and co-occurring ADHD and anxiety were compared on aggression subtypes (i.e., reactive, proactive, overt, and relational aggression). In Study 2, the moderating role of anxiety on the relation between ADHD and aggression subtypes was examined with a larger sample (N = 265) and with continuous variables. No support was found for either the attenuation or exacerbation hypothesis, and results remained consistent when separately examining hyperactivity/impulsivity and inattention symptoms of ADHD. Although ADHD symptoms were significantly associated with all aggression subtypes, this association did not remain when including symptoms of oppositional defiant disorder.

Journal of Abnormal Child Psychology: An official publication of the International Society for Research in Child and Adolescent Psychopathology. 2012 May;40:555-67.

**EVIDENCE FOR A GENERAL ADHD FACTOR FROM A LONGITUDINAL GENERAL SCHOOL POPULATION STUDY.**

**Normand S, Flora DB, Toplak ME, et al.**

Recent factor analytic studies in Attention-Deficit/Hyperactivity Disorder (ADHD) have shown that hierarchical models provide a better fit of ADHD symptoms than correlated models. A hierarchical model includes a general ADHD factor and specific factors for inattention, and hyperactivity/impulsivity. The aim of this 12-month longitudinal study was to test the generalizability of the hierarchical models of ADHD within an elementary school population of 6–9 year old children (250 boys, 260 girls). Examination of differences as a function of informant (parent vs. teacher ratings), sex, and time was conducted. Six potential factor structures for the 18 items of the SWAN (Strengths and Weaknesses of ADHD-symptoms and Normal-behavior) scale were tested using confirmatory and exploratory factor analyses. Hierarchical models with a general ADHD factor and two or three specific factors best accounted for parent and teacher reports of symptoms for both boys and girls and at two time points separated by a 12-month interval. Findings indicate that the 18 SWAN items measure a common latent trait as well as orthogonal factors or dimensions of inattention and hyperactivity/impulsivity.



Journal of Abnormal Child Psychology: An official publication of the International Society for Research in Child and Adolescent Psychopathology. 2012 May;40:543-54.

**YOUTH APPRAISALS OF INTER-PARENTAL CONFLICT AND GENETIC AND ENVIRONMENTAL CONTRIBUTIONS TO ATTENTION-DEFICIT HYPERACTIVITY DISORDER: EXAMINATION OF GxE EFFECTS IN A TWIN SAMPLE.**

**Nikolas M, Klump KL, Burt SA.**

Identification of gene x environment interactions (GxE) for attention-deficit hyperactivity disorder (ADHD) is a crucial component to understanding the mechanisms underpinning the disorder, as prior work indicates large genetic influences and numerous environmental risk factors. Building on prior research, children's appraisals of self-blame were examined as a psychosocial moderator of latent etiological influences on ADHD via biometric twin models, which provide an omnibus test of GxE while managing the potential confound of gene-environment correlation. Participants were 246 twin pairs (total n = 492) ages 6–16 years. ADHD behaviors were assessed via mother report on the Child Behavior Checklist. To assess level of self-blame, each twin completed the Children's Perception of Inter-parental Conflict scale. Two biometric GxE models were fit to the data. The first model revealed a significant decrease in genetic effects and a significant increase in unique environmental influences on ADHD with increasing levels of self-blame. These results generally persisted even after controlling for confounding effects due to gene-environment correlation in the second model. Results suggest that appraisals of self-blame in relation to inter-parental conflict may act as a key moderator of etiological contributions to ADHD.

Journal of Abnormal Child Psychology: An official publication of the International Society for Research in Child and Adolescent Psychopathology. 2012 May;40:595-606.

**EMOTION REGULATION MEDIATES THE RELATIONSHIP BETWEEN ADHD AND DEPRESSIVE SYMPTOMS IN YOUTH.**

**Seymour KE, Chronis-Tuscano A, Halldorsdottir T, et al.**

A significant literature suggests that youth diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD) are at increased risk for later depression relative to youth without ADHD. Youth with co-occurring ADHD and depression experience more serious impairments and worse developmental outcomes than those with either disorder alone, including increased rates of suicidal ideation and suicide completion. Despite these very serious outcomes, few studies have examined the mechanisms underlying the relationship between ADHD and depression in youth. The present study examined emotion regulation (ER) as a mediator of the relationship between ADHD and depressive symptoms in 69 youth between the ages of 10 and 14, with (n = 37) and without (n = 32) ADHD. Parent and youth ratings of depressive symptoms and ER were collected. Youth with ADHD reported significantly more depressive symptoms and poorer ER ability relative to youth without ADHD. ER fully mediated the relationship between ADHD and depressive symptoms. Limitations and clinical implications are discussed.

Journal of Abnormal Child Psychology: An official publication of the International Society for Research in Child and Adolescent Psychopathology. 2012 May;40:569-81.

**PREDICTORS OF BOYS' ADHD SYMPTOMS FROM EARLY TO MIDDLE CHILDHOOD: THE ROLE OF FATHER-CHILD AND MOTHER-CHILD INTERACTIONS.**

**Keown LJ.**

This prospective 3 year longitudinal study investigated preschool paternal and maternal parenting predictors of Attention-Deficit/Hyperactivity Disorder (ADHD) in a community sample of 93 school-age boys. Participants were recruited on the basis of inattention-hyperactivity at age 4 and fathers and mothers were observed interacting with their sons. Teachers, fathers, and mothers reported children's ADHD symptoms and impairment. Results from dimensional analysis showed that less observed paternal sensitivity and maternal positive regard predicted higher levels of inattentiveness in middle childhood, and that intrusive paternal behavior was predictive of hyperactive-impulsive behavior at school. In categorical analysis, less maternal warmth and sensitivity were predictive of later ADHD. These predictions held after statistical adjustment for the effects of preschool ADHD behaviors and conduct problems. At follow-up, parents of boys with ADHD reported more negative child-parent relationship perceptions than comparison parents.

Findings highlight the importance of examining responsive parenting behaviors of both fathers and mothers in relation to multi-informant ratings of ADHD symptoms.

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Journal of Attention Disorders. 2012 May;16:267-75.

**ASSOCIATION OF PARENTAL ADHD AND DEPRESSION WITH EXTERNALIZING AND INTERNALIZING DIMENSIONS OF CHILD PSYCHOPATHOLOGY.**

**Humphreys KL, Mehta N, Lee SS.**

**Objective:** To study the independent association of parental depression and ADHD on three dimensions of child psychopathology among 178 children aged 5 to 10 years.

**Method:** Self-reported measures of parental depression and ADHD as well as rating scales and structure diagnostic interviews of child internalizing, ADHD, and externalizing problems were obtained.

**Results:** Structural equation modeling indicated that parental ADHD was positively associated with a broad child problems factor after a second-order factor of child problems best accounted for the high intercorrelations among the internalizing, ADHD, and externalizing child psychopathology factors. Parental depression did not significantly predict the second-order child problems factor, but it specifically predicted the child internalizing factor.

**Conclusion:** These results suggest that parental ADHD may be a nonspecific risk factor for child psychopathology broadly, whereas parental depression may function as a specific risk factor for child internalizing problems.

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Journal of Attention Disorders. 2012 Apr;16:179-89.

**FUNCTIONAL IMPAIRMENTS IN CHILDREN WITH ADHD: UNIQUE EFFECTS OF AGE AND COMORBID STATUS.**

**Booster GD, DuPaul GJ, Eiraldi R, et al.**

**Objective:** Children with ADHD and comorbid disorders display poorer overall functioning compared with children with ADHD alone, though little research has examined the differential impact of externalizing versus internalizing comorbidities.

**Method:** This study examined the impact of internalizing and externalizing comorbidities on the academic and social functioning of 416 children with ADHD.

**Results:** Children with ADHD and a comorbid externalizing disorder (with or without a concomitant internalizing comorbidity) displayed poorer social skills than those with ADHD alone. Children with ADHD and both an externalizing and internalizing comorbidity exhibited greater homework problems than their ADHD peers with fewer than two types of comorbidity. In addition, older children displayed significantly poorer social skills and greater homework problems than younger children. There was no interaction between comorbid status and age for any measure of academic or social functioning.

**Conclusion:** Results underscore the need for early interventions to address social skills and homework difficulties for children with ADHD and comorbid externalizing disorders.

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Journal of Attention Disorders. 2012 May;16:276-83.

**PARENT RATINGS OF ADHD SYMPTOMS: GENERALIZED PARTIAL CREDIT MODEL ANALYSIS OF DIFFERENTIAL ITEM FUNCTIONING ACROSS GENDER.**

**Gomez R.**

**Objective:** Generalized partial credit model, which is based on item response theory (IRT), was used to test differential item functioning (DIF) for the Diagnostic and Statistical Manual of Mental Disorders (4th ed.), inattention (IA), and hyperactivity/impulsivity (HI) symptoms across boys and girls.

**Method:** To accomplish this, parents completed an ADHD rating scale for 403 boys and 380 girls, between 6 and 11 years of age.

**Results:** The findings indicated no DIF for all the slope parameters for both the IA and HI symptoms. For location parameters, there was no DIF for all the IA symptoms and for seven of the nine HI symptoms.



However, the effect sizes for the DIF symptoms were small. Thus, there was good support for gender equivalency for the ADHD symptoms.

**Conclusion:** These findings extend existing data on gender equivalency of ADHD symptoms, obtained using other methodologies for testing measurement equivalency.

Journal of Attention Disorders. 2012 Apr;16:190-98.

**GENDER DIFFERENCES AMONG CHILDREN WITH ADHD ON CONTINUOUS PERFORMANCE TESTS: A META-ANALYTIC REVIEW.**

**Hasson R, Fine JG.**

**Objective:** Gender differences among children with ADHD are not well understood. The continuous performance test (CPT) is the most frequently used direct measure of inattention and impulsivity. This meta-analysis compared CPT performance between boys and girls with and without ADHD.

**Method:** All peer-reviewed ADHD studies published between 1980 and 2010 that used a CPT and enabled gender comparison were included. Gender differences in commission (impulsivity) and omission (inattention) errors were analyzed.

**Results:** Included studies comprised a sample of 772 boys and 325 girls with ADHD. Findings show that boys were significantly more impulsive than girls, but no difference with inattention was found. Within-gender analysis revealed that the difference among boys with and without ADHD was significantly larger than the difference among girls with and without ADHD.

**Conclusion:** The results indicate that gender is a significant moderating factor in the assessment of core ADHD symptoms when using CPTs.

Journal of Attention Disorders. 2012 May;16:339-45.

**COMORBIDITY OF MIGRAINE WITH ADHD.**

**Fasmer OB, Riise T, Lund A, et al.**

**Objective:** The purpose of this study was to investigate how often drugs used to treat migraine and ADHD are prescribed to the same patients to assess, indirectly, the comorbidity of these disorders.

**Method:** We used data from the Norwegian prescription database for 2006, including the total Norwegian population (N = 4,640,219).

**Results:** Antimigraine drugs were prescribed to 81,225 persons (1.75% of the total population), anti-ADHD drugs to 18,481 persons (0.40%), and 284 persons were prescribed both types of drugs. There was a positive and significant association between prescription of antimigraine and anti-ADHD drugs for all age groups between 20 and 50 for both genders, with odds ratios ranging from 1.76 to 2.81.

**Conclusion:** The prescription patterns for these drugs in adult patients indicate a comorbidity between migraine and ADHD.

Journal of Attention Disorders. 2012 May;16:325-32.

**SUBSTANCE USE DISORDER AND ADHD: IS ADHD A PARTICULARLY 'SPECIFIC' RISK FACTOR?**

**Kousha M, Shahrivar Z, Alaghband-rad J.**

**Objective:** To assess the pattern of substance use disorder (SUD) in adolescents with and without history of attention—deficit/hyperactivity disorder (ADHD) using an Iranian sample in the context of a cultural background and drug availability is differing from Western countries.

**Method:** In this case- control study, the participants were interviewed by a child psychiatrist and the measures included: kiddie Schedule for Affective Disorder and Schizophrenia for school age children (K-SADS), Opium Treatment Index (OTI) and Global Assessment Functioning (GAF). Data were analyzed with chi square test and T test and fisher exact test by EPI.6 soft ware.

**Results:** Adolescents with ADHD were younger at the time of starting cigarette smoking, substance use, abuse and dependency ( $p = 0.0001$ ), a shorter period between their first-time substance use and substance dependence or abuse ( $p = 0.0001$ ), more severe substance use (for cannabis, heroine, cigarette

and drugs such as benzodiazepines  $p < 0.05$ ) and more functional impairment ( $p = 0.0007$ ). Average number of co morbid disorders were higher in ADHD group. ( $p = 0.03$ )

**Conclusion:** Although the pattern and type of substance use may be different in Iranian culture, our findings about the relationship between ADHD and SUD are similar to other western and non western countries. The presence of ADHD may over-ride cultural barriers and lower availability of drugs to the development of SUD in Iranian adolescents. Early diagnosis and treatment of ADHD may propose with better prognosis of SUD and subsequent decrease in the prevalence of SUD and the costs of SUD-related pathology in this population.

Journal of Attention Disorders. 2012 Apr;16:244-54.

**DEPRESSION AND ANXIETY AMONG TRANSITIONING ADOLESCENTS AND COLLEGE STUDENTS WITH ADHD, DYSLLEXIA, OR COMORBID ADHD/DYSLLEXIA.**

**Nelson JM, Gregg N.**

**Objective:** To investigate depressive and anxious symptomatology among transitioning adolescents and college students with ADHD, dyslexia, or comorbid ADHD/dyslexia.

**Method:** Transitioning adolescents and college students with these disorders along with a non-ADHD/dyslexia college sample completed self-report measures of depression and anxiety.

**Results:** Results indicated no differences between the college-level groups, although a main effect for gender was found and trended toward females with dyslexia reporting more symptoms of depression and anxiety than did males with dyslexia. Internalizing symptomatology differences were not found for subtypes of ADHD. Transitioning high school students with ADHD, dyslexia, or ADHD/dyslexia reported fewer symptoms of anxiety and depression than did college underclassmen with these disorders.

**Conclusion:** The unique characteristics and experiences of the college population of individuals with ADHD and/or dyslexia are discussed relative to the general adult population with these disorders.

Journal of Attention Disorders. 2012 May;16:284-94.

**COGNITIVE FUNCTIONING AND FAMILY RISK FACTORS IN RELATION TO SYMPTOM BEHAVIORS OF ADHD AND ODD IN ADOLESCENTS.**

**Forssman L, Eninger L, Tillman CM, et al.**

**Objective:** In this study, the authors investigated whether ADHD and oppositional defiant disorder (ODD) behaviors share associations with problems in cognitive functioning and/or family risk factors in adolescence. This was done by examining independent as well as specific associations of cognitive functioning and family risk factors with ADHD and ODD behaviors.

**Method:** A sample of 120 adolescents from the general population was assessed on various cognitive tasks. ADHD and ODD behaviors were measured through parental and teacher ratings based on Diagnostic and Statistical Manual of Mental Disorders (4th edition) criteria. Parents and adolescents provided information regarding measures of family risk factors.

**Results:** The results show that only cognitive functioning was associated with ADHD behaviors, and family risk factors were, independent of cognitive functioning, associated with ODD behaviors.

**Conclusion:** These results suggest that cognitive performance bears a specific significance for ADHD behaviors, whereas family risk factors have specific importance for ODD behaviors.

Journal of Attention Disorders. 2012 May;16:346-48.

**TREATING ADHD WITH AGOMELATINE.**

**Niederhofer H.**

**Objective:** Agomelatine is a relatively new antidepressant, with affinities to MT1 and MT2 (responsible for the circadian rhythm) as well as to 5-HT2C receptors. Since antidepressants have demonstrated some benefit in the treatment of ADH and because of the fact, that ADHD is often associated with sleep disorders, we assumed, that it might be a therapeutic alternative also for ADHD.

**Method:** We proved this assumption in ten ADHD patients in a placebo controlled manner.

**Results:** Agomelatine's effect was superior to that of placebo, but seems to be less than that of Methylphenidate or placebo.

**Conclusion:** If ADHD therapy with Methylphenidate or Atomoxetine is not indicated e.g. because of adverse side effects and if an ADHD patient suffers from additional sleep disorders, Agomelatine might be a helpful therapeutic alternative.

J Child Neurol. 2012 May;27:604-09.

**EFFECTS OF OSMOTIC-RELEASE METHYLPHENIDATE ON HEIGHT AND WEIGHT IN CHILDREN WITH ATTENTION-DEFICIT HYPERACTIVITY DISORDER (ADHD) FOLLOWING UP TO FOUR YEARS OF TREATMENT.**

**Durá-Travé T, Yoldi-Petri ME, Gallinas-Victoriano F, et al.**

There is some controversy concerning the potential negative influence of methylphenidate on growth. The authors reviewed clinical records of 187 patients with attention-deficit hyperactivity disorder under treatment with methylphenidate. The patients' weight, height, and body mass index were measured at diagnosis and during 4 years of follow-up. The dose of methylphenidate was gradually increased up to  $1.31 \pm 0.2$  mg/kg/d. At diagnosis, mean weight value was lower than mean weight expected for age by 0.697 kg. This difference increased to 4.274 kg (at 30 months of treatment), although it subsequently decreased to 1.588 kg (at 48 months of treatment). Mean value of height was lower than expected mean height for age by 0.42 cm at diagnosis. This difference increased to 2.69 cm (at 30 months of treatment), but it subsequently decreased to 0.83 cm (at 48 months of treatment). The relationship between nutritional status and the negative effects on the height curve in those patients would require nutritional optimization to return anthropometric variables to normal.

Journal of Child Psychology and Psychiatry. 2012 Apr;53:390-400.

**EXAMINATION OF NEUROLOGICAL SUBTLE SIGNS IN ADHD AS A CLINICAL TOOL FOR THE DIAGNOSIS AND THEIR RELATIONSHIP TO SPATIAL WORKING MEMORY.**

**Ferrin M, Vance A.**

**Background:** Neurological subtle signs (NSS) are minor neurological abnormalities that have been shown to be increased in a number of neurodevelopmental conditions. For attention deficit/hyperactivity disorder (ADHD), it remains unclear whether NSS may aid the clinical diagnostic process.

**Methods:** This study explored the association of total and specific domains of NSS in 1,055 children and adolescents with ADHD compared to 130 age-matched typically developing participants; the relationship between NSS and Spatial Working Memory (SWM) as a cognitive process integrally involved in ADHD was also assessed. To determine the diagnostic and predictive efficiency of NSS, a receiver operating curve analysis was performed and the area under the curve (AUC) quantified. The best discriminant points for differentiating between ADHD and typically developing participants and the predictive power of NSS for SWM impairment in ADHD young people were also calculated.

**Results:** Area under the curves for total NSS, smoothness/accuracy, cerebellar signs and choreo-athetoid movements scores were considered good (.84, .79, .74 and .73 respectively), and the results remained after controlling for gender and IQ. A total score of 13 or over on the Scored Developmental Neurological Examination proved to be a good threshold point for differentiating between the ADHD and typically developing participants. For ADHD children, the AUC of total NSS to distinguish between those below 25th and above 75th percentile were .77 and .73 for Spatial Span and for Between Search Errors respectively (the two SWM-dependent measures examined).

**Conclusions:** This study provides evidence suggesting that NSS may aid the clinical evaluation of a child or adolescent with ADHD. In children and adolescents with ADHD, NSS are associated with difficulties in SWM, specifically the Spatial Span and Between Search Error components.

Mol Psychiatry. 2012;17:185-92.

**IDENTIFICATION AND FUNCTIONAL CHARACTERIZATION OF THREE NOVEL ALLELES FOR THE SEROTONIN TRANSPORTER-LINKED POLYMORPHIC REGION.**

**Ehli EA, Hu Y, Lengyel-Nelson T, et al.**

A promoter polymorphism in the serotonin transporter gene (5-HTTLPR) has been reported to confer relative risk for phenotypes (depression/anxiety) and endophenotypes (amygdala reactivity). In this report, we identify and characterize three rare 5-HTTLPR alleles not previously described in the human literature. The three novel alleles were identified while genotyping 5-HTTLPR in a family-based attention deficit hyperactivity disorder clinical population. Two of the novel alleles are longer than the common 16-repeat long (L) allele (17 and 18 repeats) and the third is significantly smaller than the 14-repeat short (S) allele (11 repeats). The sequence and genetic architecture of each novel allele is described in detail. We report a significant decrease in the expression between the XL17 (17r) allele and the LA (16r) allele. The XS11 (11r) allele showed similar expression with the S (14r) allele. A 1.8-fold increase in expression was observed with the L A (16r) allele compared with the LG (16r) allele, which replicates results from earlier 5-HTTLPR expression experiments. In addition, transcription factor binding site (TFBS) analysis was performed using MatInspector (Genomatix) that showed the presence or absence of different putative TFBSs between the novel alleles and the common L (16r) and S (14r) alleles. The identification of rare variants and elucidation of their functional impact could potentially lead to understanding the contribution that the rare variant may have on the inheritance/susceptibility of multifactorial common diseases.

Neurochem Res. 2012;37:330-34.

**ALTERED BIOCHEMICAL PARAMETERS IN SALIVA OF PEDIATRIC ATTENTION DEFICIT HYPERACTIVITY DISORDER.**

**Archana E, Pai P, Prabhu BK, et al.**

Oxidative stress is one of the common causes in etiopathogenesis of attention deficit hyperactivity disorder (ADHD). Hence, the salivary levels of protein thiols, ceruloplasmin, magnesium and pseudocholinesterase were estimated in children with ADHD. The symptoms of ADHD were identified using Conner's rating and DSM IV criteria. Saliva was collected and assessed for the levels of protein thiols, ceruloplasmin, magnesium and pseudocholinesterase, spectrophotometrically. It was also checked for pH and the flow rate was noted down. There was a significant increase ( $P < 0.001$ ) in the salivary protein thiols and pseudocholinesterase levels in ADHD children when compared to controls. Ceruloplasmin levels did not show any significant change. Magnesium levels were significantly decreased ( $P < 0.001$ ) in cases when compared to controls. Further, a receiver operating characteristic curve for validity of the biochemical parameters in saliva of ADHD children indicated a sensitivity and specificity above 90% for protein thiols and magnesium values. Our study shows that protein thiols, magnesium, and pseudocholinesterase might have a role in the pathogenesis of ADHD and saliva can be effectively used as a non-invasive tool for evaluation of such children.

Neuropsychology. 2012 May;26:278-87.

**EXECUTIVE FUNCTIONS IN GIRLS WITH ADHD FOLLOWED PROSPECTIVELY INTO YOUNG ADULTHOOD.**

**Miller M, Ho J, Hinshaw SP.**

**Objective:** We prospectively followed an ethnically and socioeconomically diverse sample of girls with ADHD ( $n = 140$ ) and a matched comparison group ( $n = 88$ ) into young adulthood (Mean = 19.6), 10 years after childhood initial assessments, to evaluate neuropsychological functioning. We hypothesized that neuropsychological deficits would persist through young adulthood for those with ADHD, and that those with continuing ADHD symptomatology in young adulthood would show the largest impairments.

**Method:** Neuropsychological measures at follow-up emphasized executive functions (EF) including planning, organization, inhibitory control, sustained attention, working memory, and set shifting.

**Results:** Parallel to findings from childhood and adolescence, the girls with childhood-diagnosed ADHD displayed medium to large deficits in EF relative to comparisons at follow-up, even with statistical control of baseline demographic and comorbidity variables. The addition of IQ as a covariate attenuated differences but several remained significant. Comparisons between the inattentive and combined subtypes of ADHD

yielded nonsignificant results with small effect sizes. EF impairments were evident in both participants whose ADHD diagnoses persisted and in those whose ADHD symptoms had remitted to a nondiagnosable level; both subgroups had more EF deficits than those who did not meet criteria for ADHD in either childhood or young adulthood.

**Conclusions:** Those in both the persistent and remitted ADHD groups showed impairments in EF relative to comparisons and generally did not differ from each other. Overall, childhood ADHD in girls portends neuropsychological/EF deficits that persist for at least 10 years.

Neurosci Behav Physiol. 2011;41:906-10.

#### **DIAGNOSIS OF ATTENTION DEFICIT HYPERACTIVITY DISORDER USING A CONDITIONED REFLEX APPROACH.**

**Albertin SV.**

A conditioned reflex method was developed for the diagnosis of attention deficit hyperactivity disorder using an automated apparatus containing a radial maze with a hidden search object (reward), where successful task solution depended on the subject's attention to the spatial locations of sensory signals indicating the location of the search object in the maze. This method increases the accuracy of the diagnosis of attention deficit hyperactivity in children of preschool and school age and decreases test duration.

Nutrition. 2012;28:242-49.

#### **DIETARY PATTERNS AND ATTENTION DEFICIT HYPERACTIVITY DISORDER AMONG IRANIAN CHILDREN.**

**Azadbakht L, Esmailzadeh A.**

**Objective:** This study was conducted to assess the relation of major dietary patterns identified by factor analysis to attention-deficit/hyperactivity disorder (ADHD) in a group of Iranian school-age children.

**Methods:** This cross-sectional study was conducted in 375 school-age children in Tehran, Iran. We assessed usual dietary intakes by a semiquantitative food-frequency questionnaire. The presence of ADHD was diagnosed using the questionnaire of the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition. Major dietary patterns were identified by factor analysis.

**Results:** The prevalence of ADHD was 9.7% in this population. We identified four major dietary patterns: "healthy," "Western," "sweet," and "fast food." After controlling for potential confounders, children in the top quintile of the sweet dietary pattern score had greater odds for having ADHD compared with those in the lowest quintile (odds ratio 3.95, 95% confidence interval 1.16-15.31, P for trend = 0.03). Greater adherence to the fast-food dietary pattern was significantly associated with a higher risk of having ADHD (odds ratio 3.21, 95% confidence interval 1.05-10.90, P for trend = 0.03). No overall significant associations were seen between the healthy or Western dietary pattern and ADHD.

**Conclusion:** We found significant independent associations between the sweet and fast-food dietary patterns and the prevalence of ADHD. Prospective studies are required to confirm these findings.

PNAS Proceedings of the National Academy of Sciences of the United States of America. 2012 Apr;109:6769-74.

#### **DISTINCT NEUROPSYCHOLOGICAL SUBGROUPS IN TYPICALLY DEVELOPING YOUTH INFORM HETEROGENEITY IN CHILDREN WITH ADHD.**

**Fair DA, Bathula D, Nikolas MA, et al.**

Research and clinical investigations in psychiatry largely rely on the de facto assumption that the diagnostic categories identified in the Diagnostic and Statistical Manual (DSM) represent homogeneous syndromes. However, the mechanistic heterogeneity that potentially underlies the existing classification scheme might limit discovery of etiology for most developmental psychiatric disorders. Another, perhaps less palpable, reality may also be interfering with progress—heterogeneity in typically developing populations. In this report we attempt to clarify neuropsychological heterogeneity in a large dataset of typically developing youth and youth with attention deficit/hyperactivity disorder (ADHD), using graph theory and community detection. We sought to determine whether data-driven neuropsychological subtypes could be discerned in



children with and without the disorder. Because individual classification is the sine qua non for eventual clinical translation, we also apply support vector machine-based multivariate pattern analysis to identify how well ADHD status in individual children can be identified as defined by the community detection delineated subtypes. The analysis yielded several unique, but similar subtypes across both populations. Just as importantly, comparing typically developing children with ADHD children within each of these distinct subgroups increased diagnostic accuracy. Two important principles were identified that have the potential to advance our understanding of typical development and developmental neuropsychiatric disorders. The first tenet suggests that typically developing children can be classified into distinct neuropsychological subgroups with high precision. The second tenet proposes that some of the heterogeneity in individuals with ADHD might be “nested” in this normal variation.

Psychiatry Clin Neurosci. 2012;66:53-63.

**NATURALISTIC EXPLORATION OF THE EFFECT OF OSMOTIC RELEASE ORAL SYSTEM-METHYLPHENIDATE ON REMISSION RATE AND FUNCTIONAL IMPROVEMENT IN TAIWANESE CHILDREN WITH ATTENTION-DEFICIT-HYPERACTIVITY DISORDER.**

**Tzang RF, Wang YC, Yeh CB, et al.**

**Aim:** To determine the differences in the remission rate, recovery rate, functional improvement, and treatment adherence related to treatment with short-acting immediate-release methylphenidate (IR-MPH) and long-acting osmotic-release oral system-methylphenidate (OROS-MPH) in a naturalistic setting among Taiwanese children with attention-deficit-hyperactivity disorder (ADHD).

**Methods:** A total of 757 children with ADHD, aged 6-18 years, was evaluated using the following in order determine functional improvement and treatment adherence: the Chinese version of the Swanson, Nolan, and Pelham, version IV scale (SNAP-IV-C), Clinical Global Impression-ADHD-Severity (CGI-S) to measure remission and recovery rates, the Chinese version of the Social Adjustment Inventory for Children and Adolescents (CSAICA), and caregiver's satisfaction rate, treatment adherence, and frequency of adverse effects.

**Results:** According to the SNAP-IV-C scores, the remission rate was 30.72%, and the recovery rate was 16.38%. Compared to short-acting IR-MPH, OROS-MPH was associated with greater functional improvement and treatment adherence among children with ADHD.

**Conclusion:** OROS-MPH treatment at the adequate dosage can achieve higher remission and recovery rates, produce greater functional improvement, and result in better treatment adherence than IR-MPH treatment.

Social Psychiatry and Psychiatric Epidemiology. 2012 May;47:763-69.

**PREVALENCE OF THE ADHD PHENOTYPE IN 7- TO 9-YEAR-OLD CHILDREN: EFFECTS OF INFORMANT, GENDER AND NON-PARTICIPATION.**

**Ullebø AK, Posserud MB, Heiervang E, et al.**

**Purpose:** To estimate the prevalence of the ADHD phenotype based on parent and teacher reports in a general population sample of 7- to 9-year-old Norwegian children and evaluate the effect of parent attrition, gender and informant on the prevalence estimate.

**Methods:** The population consisted of all children (N = 9,430) attending 2nd–4th grade in the City of Bergen, Norway. The 18 symptoms of ADHD corresponding to the SNAP-IV and DSM-IV were included in the Bergen Child Study questionnaire to teachers and parents. Teacher information was available for 9,137 children (97%) and information from both informants was available for the 6,237 children (66%) whose parents agreed to participate in the study.

**Results:** The prevalence of the ADHD phenotype based on the combination of parent and teacher reports was 5.2% among participants. Teacher ratings of non-participants had a doubled rate of ADHD high scorers with an OR of 2.1 (95% CI, 1.9–2.4). The non-participant ADHD high scorers had more inattentive and fewer hyperactive/impulsive symptoms as compared to participating ADHD high scorers. Teachers reported high scores of hyperactivity/impulsivity and the combined symptom constellation much more



frequently in boys than girls, while the difference between genders was less marked according to parent reports.

**Conclusions:** The ADHD phenotype was twice as prevalent among non-participants as among participants. Reported prevalences in population studies are therefore likely to be underestimates, if such attrition bias is not accounted for. Choice of informant, criteria for symptom count, definitions of subtypes and gender differences influence the prevalence estimates of the ADHD phenotype.

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## Assessing Attentional Systems in Children with Attention Deficit Hyperactivity Disorder

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### Abstract

The aim of this study was to evaluate the efficiency and interactions of attentional systems in children with Attention Deficit Hyperactivity Disorder (ADHD) by considering the effects of reinforcement and auditory warning on each component of attention. Thirty-six drug-naïve children (18 children with ADHD/18 typically developing children) performed two revised versions of the Attentional Network Test, which assess the efficiency of alerting, orienting, and executive systems. In feedback trials, children received feedback about their accuracy, whereas in the no-feedback trials, feedback was not given. In both conditions, children with ADHD performed more slowly than did typically developing children. They also showed impairments in the ability to disengage attention and in executive functioning, which improved when alertness was increased by administering the auditory warning. The performance of the attentional networks appeared to be modulated by the absence or the presence of reinforcement. We suggest that the observed executive system deficit in children with ADHD could depend on their low level of arousal rather than being an independent disorder.

**Keywords:** Attention Deficit Hyperactivity Disorder (ADHD); Alerting; Attentional orienting; Executive function; Feedback; Attentional Network Test

### Introduction

#### *Attention Deficit Hyperactivity Disorder*

Attention Deficit Hyperactivity Disorder (ADHD) is the most common neurodevelopmental disorder in children (Goldman, Genel, Bezman, & Slanetz, 1998; Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007), and it is characterized by inattentiveness, over-activity and impulsiveness (APA, 2000). Inattention is the most commonly studied symptom of ADHD, but it is not clearly defined. Although the diagnosis of ADHD implies attentional deficits, attention is not formally defined in cognitive terms by the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders-IV (DSM-IV). It is not clear which specific attentional ability is reduced in ADHD. In the absence of this information, it is difficult to understand the core attentional deficit of ADHD and to implement a specific attention rehabilitation treatment for ADHD patients.

#### *Attentional Systems*

Neuropsychologists consider attention to be a multidimensional ability (Corbetta, Pathel, & Shulman, 2008; Fan, Flombaum, & McCandliss, 2003; Posner & Petersen, 1990; Raz, 2004; Thiel, Zilles, & Fink, 2004) that can be thought of as an organic system (Posner & Fan, 2008). According to the model by Posner and Petersen (1990), attention involves

**Table 1.** All the studies that have used the ANT in order to compare attentional systems in children with ADHD and TDC

Authors	ANT typology	Participants	ADHD medication	Participants' age	Differences between children with ADHD and TDC				
					Accuracy	RT	Alerting effect	Orienting effect	Conflict effect
Oberlin and colleagues (2005)	Revised OV <sup>a</sup>	30 ADHD <sup>b</sup> , 33 Controls	25 off medication (M) 14 on M <sup>c</sup>	18–30 y	TDC = ADHD	TDC < ADHD off M, C = ADHD on M	TDC = ADHD	TDC = ADHD	TDC = ADHD
Konrad and colleagues (2006)	Lateralized ANT <sup>d</sup>	16 ADHD, 16 TDC	No	8–12 y	TDC > ADHD	TDC = ADHD	TDC = ADHD	TDC = ADHD	TDC < ADHD
Booth and colleagues (2007)	CV	42 ADHD, 24 TDC	13 No, 29 No for 18 h or more	7–13 y	TDC > ADHD	TDC < ADHD	TDC = ADHD	TDC = ADHD	TDC = ADHD
Lampe and colleagues (2007)	OV	22 ADHD, 20 ADHD + BPD, 21 BPD, 20 Controls	No for 4 weeks or more	18–45 y	—	TDC < ADHD	TDC = ADHD	TDC = ADHD	TDC < ADHD
Adólfssdóttir and colleagues (2008)	CV	45 ADHD, 121 TDC	9 No, 36 Yes	7.9–11.9 y	TDC > ADHD	TDC = ADHD	TDC = ADHD	TDC = ADHD	TDC = ADHD
Johnson and colleagues (2008)	OV	73 ADHD, 73 TDC	No for 24 h or more	Mean = 12.9 y	TDC > ADHD	TDC < ADHD	TDC = ADHD	TDC = ADHD	TDC < ADHD
Gupta and Kar (2009)	CV	120 ADHD, 120 TDC	—	6–9 y	—	TDC < ADHD	TDC = ADHD	TDC > ADHD	TDC < ADHD
Mullane and colleagues (2010)	Revised OV <sup>e</sup>	26 ADHD-C, 22-ADHD-I, 45 TDC	42 Yes, 27 No for 42 h or more	6–12 y	TDC > ADHD	TDC < ADHD	TDC < ADHD	TDC = ADHD	TDC < ADHD
Poynter and colleagues (2010)	Revised lateralized ANT <sup>f</sup>	15 = Low ADHD (LA) scores, 21 = High ADHD (HA) scores <sup>g</sup>	—	18–33 y	LA = HA	LA = HA	LA = HA	LA > HA in left visual field	LA < HA in left visual field

Notes: ANT = Attention Network Test; ADHD = Attention Deficit Hyperactivity Disorder; RT = reaction time; TDC = typically developing children; BPD = borderline personality disorder; OV = original version of the ANT (Fan et al., 2002); CV = children version of the ANT (Rueda et al., 2004); LA = low ADHD scores; HA = high ADHD scores; Y = years; Alerting effect = RT warning present trials – RT warning absent trials; Orienting effect = RT valid trials – RT Invalid trials; Conflict effect = RT incongruent trials – RT congruent trials.

<sup>a</sup>Including additional visual distractions.

<sup>b</sup>ADHD diagnosis was made by family physician prior to the age of 8.

<sup>c</sup>Nine participants with ADHD did the task both on and off medication.

<sup>d</sup>Including 20% trials with an invalid cue.

<sup>e</sup>The ANT included 50% of Flanker Task trials and 50% of Simon Task trials; furthermore, it included 50% of Invalid Trials and 50% of trials with Auditory Tone.

<sup>f</sup>Greene and colleagues (2008).

<sup>g</sup>Scores on the attention/memory subscale of the Conners' Adult ADHD Rating scales.



However, Booth and colleagues (2007) found stronger alerting effects in children with ADHD/I than in both children with ADHD/C and control children.

Taken together, these negative findings regarding orienting may support other results that indicate the presence of a pre-served orienting network in ADHD (Berger & Posner, 2000; see also Huang-Pollock & Nigg, 2003). However, these results may also be due to the inability to estimate the attentional costs of the reorienting process. The absence of invalid cues might also make the task too easy for an efficient evaluation of the executive system. These experimental features could explain the null results with regard to conflict found by many authors (Adólfssdóttir et al., 2008; Booth et al., 2007; Oberlin et al., 2005). It is notable that Konrad, Neufang, and Hanisch (2006) found a dysfunction in the executive system only when invalid trials (20%) were introduced. Additionally, impairments in conflict resolution were found in children with ADHD when the ANT was made more difficult by introducing additional distractions (Mullane, Corkum, Klein, McLaughlin, & Lawrence, 2010). However, an impaired performance in the executive system of children with ADHD was also detected using the original version (Johnson et al., 2008) and a child-oriented version (Gupta & Kar, 2009) of the ANT. It is not easy to provide a cohesive explanation for these inconsistent findings. One possibility is that the use of ADHD medication could be responsible for many of the inconsistencies. Gupta and Kar (2009) did not report information regarding the drug treatment of the tested children with ADHD, whereas in the work of Johnson and colleagues (2008), any stimulant medication was withdrawn for at least 24 h prior to testing. Among the various studies using the ANT (Table 1), only Konrad and colleagues (2006) included children without a prior history of stimulant treatment. In light of these findings, it is important to emphasize that our participants were drug naïve, and this could highlight the attentional condition in ADHD and partially explain the contrasting results present in the literature.

Nevertheless, drug treatment could not be the only factor affecting these contrasting results. Certainly, other confounding variables should be considered, such as co-morbid disorders, ADHD subtypes, age, and IQ. Finally, although many inconsistent behavioral results have been reported, functional Magnetic Resonance Imaging (fMRI) findings suggest a hypo-activation of specific brain regions in children with ADHD during alerting, conflict, and re-orienting performance (Konrad et al., 2006).

#### *Aims and Hypotheses of this Study*

In the current study, we aim to evaluate two revised versions of Rueda's ANT. In these experiments, we manipulated alertness and motivation. Alertness was manipulated by introducing an auditory tone (warning) in 25% of the trials. To evaluate the orienting system, both spatial and central cues were replaced by peripheral non-predictive cues (50% valid and 50% invalid trials). In Rueda's version of the ANT, the presence of feedback in every trial does not allow for the evaluation of whether individual attentional systems (specifically the executive system) are affected by motivational aspects. Thus, we manipulated the effect of motivation by introducing feedback in one task (feedback trials), but not in the other (no-feedback trials). The manipulation of feedback could allow us to evaluate the impact of reinforcement on attentional systems in children with ADHD. This issue is very relevant. A recent review (Luman, Oosterlaan, & Sergeant, 2005) indicates that reinforcement contingencies have a positive impact on task performance and levels of motivation in both children with ADHD and typically developing children, and this effect is more prominent in children with ADHD. However, it is important to note that other reports suggest that the performance of both children with ADHD and typically developing children on go/no-go tasks are not enhanced by feedback (e.g., Wodka et al., 2007). The feedback manipulation could explain these inconsistent results.

This study was conducted to test the attentional deficits in children with ADHD and to assess how the attentional systems interact with each other when compared with typically developing children. Based on previous behavioral, anatomical, and functional imaging evidence, we predicted that children with ADHD would show an overall performance impairment (i.e., longer mean RT and poorer accuracy) compared with children with normal development. Specifically, children with ADHD should show a deficit in the alerting network, as reported by longer mean RT, and this effect should be especially prominent under the no-warning condition.

Second, we hypothesized that the auditory warning should speed up RT in all children by increasing phasic alertness (Callejas et al., 2004, 2005), and children with ADHD should benefit more from the alerting effect due to their alertness disorder (O'Connell et al., 2006). It is important to note that this warning manipulation could create a situation where children with ADHD and typically developing children have a similar alerting level. If alerting is solely responsible for the reduced performance in children with ADHD, the presence of a warning should improve the overall ADHD performance, particularly for orienting (Callejas et al., 2004, 2005).

Our third hypothesis deals with the conflict network, as denoted by a longer mean RT in an incongruent flanker condition compared with a congruent flanker condition. Based on the above assumptions, this network should be impaired in children with ADHD, especially in the no-warning condition. In fact, if we argue that the executive dysfunctions in children with ADHD depend on their lowered alertness, then the increase in alerting produced by the warning should improve their executive

performances. In normal adults, an alerting condition interferes with a conflict solution (Fan et al., 2009); thus, typically developing children should be delayed in responding to incongruent flankers in the warning condition.

We also hypothesize that children with ADHD should not show a deficit in the orienting network, as observed by previous studies (Huang-Pollock & Nigg, 2003).

Finally, reinforcement contingencies (the presence of feedback) should have a positive impact on task performance and motivation for both children with ADHD and typically developing children, but this effect should be more prominent in children with ADHD (Luman et al., 2005).

In conclusion, this work aims to assess the functioning of attentional systems and their interactions in children with ADHD. To the best of our knowledge, this is the first study designed to clearly delineate the specific attentional deficits in drug-naïve children with ADHD and to assess whether motivation and alerting could modulate the efficiency of the other attentional systems in this attentional disorder.

## Methods

### Participants

Thirty-six children participated in the study: 18 were diagnosed as ADHD (17 men/1 woman [should be noted that the gender ratio does not reflect that typical of ADHD; however, the male/female ratio referring to larger samples of children with ADHD is not necessarily the same when considering such a small group]), and 18 were typically developing children (17 men/1 woman). All children with ADHD were drug-naïve patients first admitted to the Day Hospital of the Child Psychiatry Unit of the University of Rome “Tor Vergata.” Children included in this study did not have a prior history of stimulant treatment. A psychopathological evaluation was performed by a team of child psychiatrists by means of the Kiddie Schedule of Affective Disorders (K-SADS; Kaufman, Birmaher, Brent, Rao, & Ryan, 1996), the Conners’ Parent Rating Scale, the Conners’ Teacher Rating Scale (Conners, 1989), the Children Depression Inventory (Kovacs, 1985), and the Multidimensional Anxiety Scale for Children (March, 1997). The inclusion criteria for this study were the diagnosis of ADHD (based on the DSM-IV criteria and confirmed by K-SADS and by both Parents and Teachers Conners scores), no history of mental retardation, brain trauma, neurological diseases, or physical impairment, a lack of co-morbid mental disorders with the exception of oppositional defiant disorder (ODD), and no learning disabilities.

Control group participants were gender- and age-matched with the ADHD group and taken from a wider group of 50 children recruited from two public schools in Rome. The children in the control group had no history of cerebral injury or other neurological or psychiatric disorders.

**Table 2.** Participant demographic and descriptive characteristics

	Children with ADHD	Typically developing children	<i>F</i>	<i>p</i> -value
Age	10.1 (± 1.7)	10 (± 1.2)	0.11	.74
PCM- and PSM-correct responses	35.2 (± 8.9)	35.4 (± 4.3)	0.01	.92
Number of children with ADHD-I	10			
Number of children with ADHD-C	8			
Parents Inattention Conners scores	64.6 (± 9.1)			
Parents Hyperactivity Conners scores	63.3 (± 10.6)			
Parents ADHD index	64.6 (± 9.4)			
Teachers Inattention Conners scores	69.4 (± 12.2)			
Teachers Hyperactivity Conners scores	71.7 (± 11.2)			
Teachers ADHD index	74.2 (± 13.9)			
ADHD/I: number of inattention symptoms	6.3 (± 1.9)			
ADHD/I: number of hyperactivity symptoms	3.5 (± 0.5)			
ADHD/I: number of impulsivity symptoms	1.5 (± 0.7)			
ADHD/C: number of inattention symptoms	4.5 (± 2.9)			
ADHD/C: number of hyperactivity symptoms	4.8 (± 1.2)			
ADHD/C: number of impulsivity symptoms	2.5 (± 0.5)			
Oppositional defiant disorder	2	0		
Conduct disorder	0	0		
Learning disabilities	0	0		
Depression/Anxiety disorders	0	0		

*Notes:* ADHD = Attention Deficit Hyperactivity Disorder; PCM = Progressive Colored Matrices; PSM = Progressive Standard Matrices; ADHD/I = children showing prevalently inattentive symptoms (APA, 2000); ADHD/C = children showing inattentiveness and hyperactivity/impulsiveness symptoms (APA, 2000).

All children age 11 and older had a full-scale IQ that fell above the 75th percentile on the Progressive Colored Matrices (Raven, Court, & Raven, 1990; Raven, Raven, & Court, 1993), and all children age 10.5 or younger had an IQ >80 on the Progressive Standard Matrices (Raven et al., 1990, 1993). The presence of ADHD in control children was assessed via an independent evaluation by the teacher and one parent who completed a DSM-IV-TR report card (APA, 2000). Any child with a possible indication of ADHD was not considered. The mean age and IQ scores of the two groups did not significantly differ. The demographic data of the sample are reported in Table 2. The procedure used in this study was approved by the Child Psychiatry and Neurology Institute Ethical Committee, and written informed consent was given by all of the parents or legal guardians of the participants included in the study prior to the testing.

### Apparatus

The stimuli were presented using E-Prime software on a Pentium 4 PC and were displayed on a 21-inch color VGA monitor from a viewing distance of approximately 56 cm (with a headrest). Responses were collected via a mouse, and a headphone was used to administer the acoustic stimuli.

### Feedback Trials

**Stimuli.** For an extensive and detailed description of both the stimuli and the procedure, see Rueda and colleagues (2004). Each trial began with the presentation of a central cross (visual angle of  $1^\circ$ ). The target was a left- or right-pointing yellow fish ( $1.6^\circ$ ) presented at the center of the screen. The fish was presented either alone (baseline trials) or flanked on both sides by two yellow fish pointing either in the same direction (congruent trials) or in the opposite direction (incongruent trials). The distance between the fish was  $0.21^\circ$ . The target and flankers subtended  $8.84^\circ$  and were presented at  $1^\circ$  above or below the fixation point over a blue–green background. The cue was an asterisk of  $1^\circ$  presented for 150 ms, and it could be presented at the position of the upcoming target (valid cue condition), in the opposite location (invalid cue condition), or above and below the fixation cross (double cue condition), or it could be absent (no-cue condition). Fig. 1 shows a schematic of the cue and the flanker conditions.

The auditory and visual feedback was an animation showing the target fish blowing bubbles and exclaiming “Woohoo!” when a correct response was given. Incorrect responses were followed by a single tone and no animation of the fish. The auditory warning stimulus was 2000 Hz and lasted 50 ms.

**Procedure.** Subjects were tested individually in a silent and dimly illuminated room. Each trial began with a fixation period of variable duration (400–1600 ms). This was followed by a warning stimulus lasting 50 ms in 25% of the trials. Next, a cue of

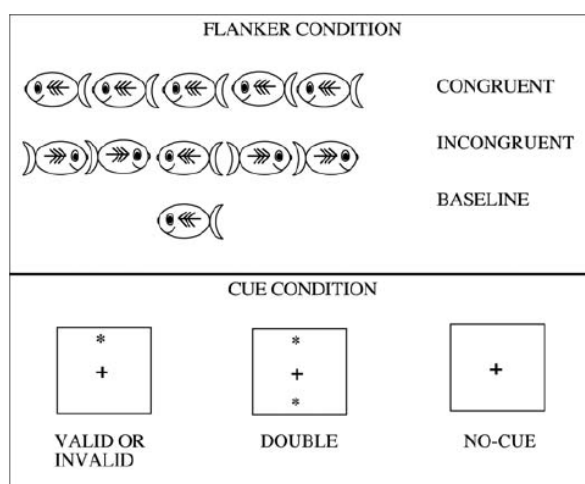


Fig. 1. Schematic representation of both flanker and cue conditions. At the top of the figure, the stimulus target is represented by the fish in the central position. It must be emphasized that the figure provides a simplified version of the stimuli; in fact, the same stimuli of Rueda and colleagues (2004) were used in the present experiment.



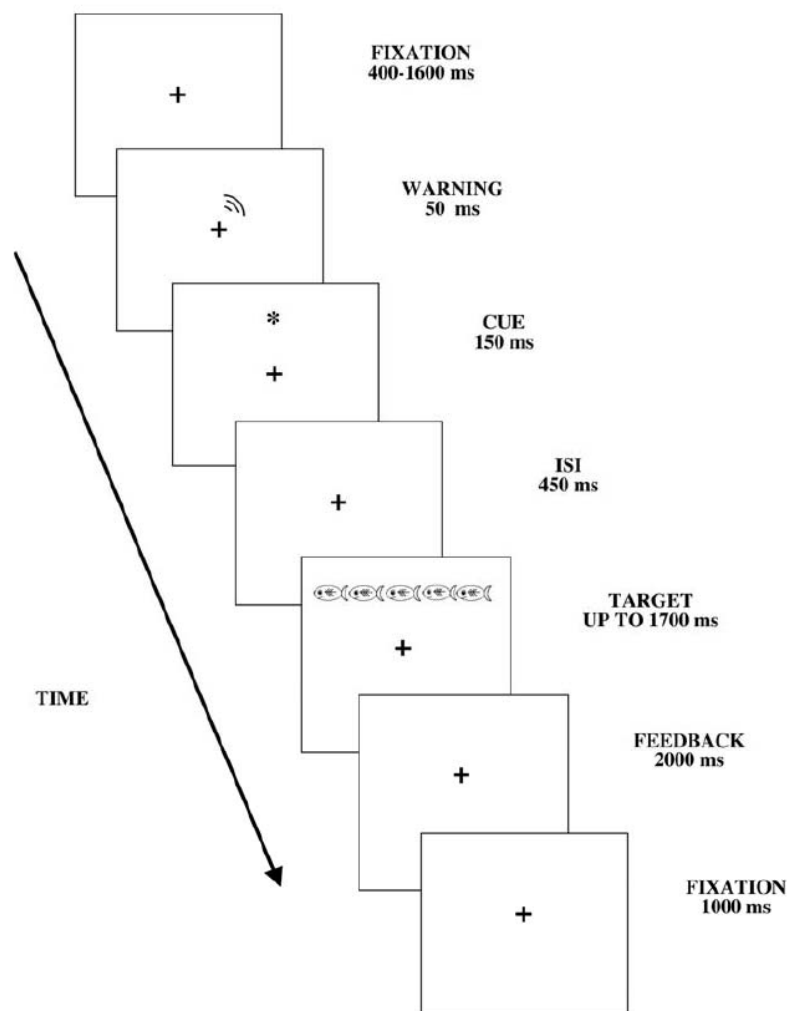


Fig. 2. This figure shows an example of the experimental procedure described in the experiment including feedback trials.

150 ms was presented. After a fixation period of 450 ms, the target was presented until the participant responded with a limit of 1700 ms. Both the auditory and the visual feedback were given following correct responses, and only the auditory feedback was given following incorrect responses.

The fixation point was at the center of the screen throughout the trial. The sequence of the events for each trial is shown in Fig. 2.

The central fish was flanked by two fish on each side, which were pointing in either the same direction (congruent condition) or the opposite direction (incongruent condition) as the central fish. The difference between these two conditions is thought to be an index of executive control. This so-called “conflict effect” is calculated by subtracting the mean RT of the congruent flanking conditions from the mean RT of incongruent flanking conditions. The two conditions differ only in the information given by the flankers. When the images are congruent, they provide a facilitating effect on the discrimination of the target stimulus, whereas incongruent flankers distract participants. Visual cues are used to separately assess the alerting (improved performance following a double cue) and orienting (an additional benefit when the cue correctly indicates the target location, i.e., a valid vs. invalid cue) attentional functions. The validity effect is calculated by subtracting the mean RT of the valid cue conditions from the mean RT of the invalid conditions. Both invalid and valid cues alert the participant to the forthcoming appearance of the target, but only the valid cue provides spatial information, which allows subjects to orient their attention

to the appropriate spatial location. Therefore, the RT difference between valid and invalid cues provides a measure of orienting attention (Fan et al., 2002, 2009). In the no-cue or double-cue conditions, attention tends to be diffused across the two potential target locations. Neither of these conditions provided spatial information about the target stimulus position, but the double-cue alerts the participant to the imminent appearance of the target. Therefore, the alerting effect is calculated by subtracting the mean RT of the double-cue conditions from the mean RT of the no-cue conditions. This represents the benefit of alerting on the speed of the response to the target.

After a 24-trial practice block, participants performed two experimental blocks of 240 trials: 24 valid, 24 invalid, 16 double-cue, and 16 no-cue trials for each flanker condition. The entire experiment comprised 480 trials. Children with ADHD executed the task in a silent room in the clinic, and the controls were tested in a room of their own school with the same experimental conditions.

**Task.** The task was to identify the direction of the centrally presented fish by clicking the right or the left button on the mouse. The instructions given were similar to those used by Rueda and colleagues (2004). Participants were told to pay attention to the central fish and to fixate on the cross in the center of the screen throughout the entire task. They were instructed to respond as quickly and accurately as possible.

The practice block took approximately 3 min, and each block was approximately 25 min. The entire session lasted approximately 60 min. The children could take a break at the end of the practice block and between the experimental blocks.

#### No-Feedback Trials

The participants, stimuli, and procedure were the same as those described for the feedback trials. The only difference was the absence of feedback. The administration of the two trial blocks was counterbalanced among participants, and they were performed on two different days.

**Experimental design.** According to a consolidated ANT analysis, only the RTs of correct responses ranging between 200 and 1400 ms were considered (Rueda et al., 2004). Because the RTs in the baseline and congruent flanker conditions did not differ ( $p = .73$ ), the RTs from the baseline trials were disregarded for subsequent analyses. A *Group* (ADHD, Control)  $\times$  *Warning* (Present, Absent)  $\times$  *Cue* (Valid, Invalid, Double, No-cue)  $\times$  *Flanker* (Congruent, Incongruent) mixed-design analysis of variance (ANOVA) was performed on both the mean RTs of the correct responses and mean errors. The warning present/absent conditions were used to evaluate the auditory alertness. Double and no-cue conditions assessed visual alertness. Valid and invalid trials evaluated orienting, and congruent and incongruent flanker trials provided a measure of executive functions.

To estimate the efficiency of each attentional system, thus enabling us to compare the results of this study with previous studies using the ANT (Callejas et al., 2004, 2005; Fan et al., 2002; Fuentes & Campoy, 2008), and to assess the effect of auditory alertness on the other two networks (orienting and executive), separate *Group*  $\times$  *Warning* ANOVAs were performed on the “orienting effect” (RT invalid-cue – RT valid-cue) and the “conflict effect” (RT incongruent trials – RT congruent trials). The orienting effect provides a measure of the orienting system, and the conflict effect is a measure of the executive control system.

*Post hoc* comparisons were conducted using either the least significant difference test (repeated measures) or the Duncan test (mixed measures).

An  $\alpha$ -value of 0.01 was used to establish statistical significance for all analyses.

## Results

#### Feedback Trials

**Reaction time analysis.** Table 3 shows the mean RT ( $\pm$  SD) for each experimental condition. All main effects were significant (Table 4), with children with ADHD showing slower RTs compared with typically developing children. Children with ADHD had faster RT when the tone was present than when it was absent. The “Cue” effect revealed no difference between valid and invalid trials, but both conditions yielded faster RTs than the double-cue ( $p < .01$ ) and no-cue ( $p < .0001$ ) trials. RTs in the double-cue trials were faster than RTs in the no-cue trials ( $p < .00001$ ). Finally, the incongruent trials yielded slower RTs compared with the congruent trials.

A “Group  $\times$  Warning” interaction— $F(1,34) = 10.84$ ,  $p < .01$ , partial  $\eta^2 = 0.24$  (Fig. 3)—demonstrated a slower RT in the absent warning condition (mean RT = 688.28 ms) than in the present warning condition (mean RT = 645.91 ms;  $p < .0001$ )

**Table 3.** Mean ( $\pm$ SD) RT of correct responses and mean errors for each condition in children with ADHD and typically development children, for feedback and no-feedback trials

Warning	Flanker	Cue	Feedback						No-feedback					
			ADHD			TDC			ADHD			TDC		
			Mean	SD	%E	Mean	SD	%E	Mean	SD	%E	Mean	SD	%E
No-warning	CON	V	646.25	164.50	6.22	494.03	64.35	2.67	639.17	164.68	9.87	469.33	77.82	12.89
		I	618.31	122.84	7.50	494.86	59.71	3.00	614.14	153.52	5.75	477.06	70.76	11.00
		D	622.67	108.78	7.94	520.06	62.06	1.56	632.61	142.21	5.94	501.81	65.63	11.89
		NC	717.97	144.47	7.78	565.81	55.61	1.33	698.06	141.45	8.87	540.42	63.09	8.72
	INC	V	694.42	153.67	10.94	547.11	76.82	6.39	682.00	151.35	12.87	505.06	96.26	15.28
		I	697.69	179.46	15.02	549.31	80.06	5.61	681.14	149.70	12.06	510.72	88.31	14.44
		D	740.89	223.38	14.11	568.83	72.99	5.39	701.47	123.82	16.69	533.72	100.52	15.50
		NC	768.03	151.65	9.06	620.67	80.36	5.89	772.08	164.57	10.25	603.39	86.84	14.39
Warning	CON	V	603.36	130.89	8.72	494.94	63.29	3.11	635.86	141.91	6.44	458.50	65.85	13.28
		I	581.92	119.70	11.50	487.06	49.79	1.33	598.86	139.55	10.94	457.25	105.01	13.33
		D	625.92	143.84	5.17	503.03	65.86	0.61	621.42	145.74	7.69	485.08	84.60	9.56
		NC	679.72	172.29	8.52	572.39	107.33	0.67	682.78	174.91	9.00	513.72	57.48	6.89
	INC	V	638.50	130.77	16.50	544.86	113.59	5.56	633.33	136.03	12.94	492.56	109.17	16.50
		I	658.03	180.15	8.22	523.83	79.30	4.56	654.39	133.93	14.06	488.61	95.25	13.33
		D	669.53	151.08	12.33	585.25	67.04	5.44	659.17	113.47	13.75	539.83	104.31	14.94
		NC	710.31	188.40	10.22	610.72	85.10	3.28	717.00	188.98	13.06	587.44	88.03	9.67

Notes: RT = reaction time; TDC = typically developing children; SD = standard deviation; %E = mean percentage of errors; CON = congruent; INC = incongruent; V = valid; I = invalid; D = double-cue; NC = no-cue.

**Table 4.** Main effects and mean RT in feedback trials and no-feedback trials in children with ADHD and in TDC

Main effects	Feedback				No-Feedback			
	F	p-value	Partial $\eta^2$	Means	F	p-value	Partial $\eta^2$	Means
Group	12.2	.001	0.26	ADHD 669, TDC 566	18.1	.001	0.35	ADHD 666, TDC 527
Warning	17.1	.001	0.33	Warning 593, No-warning 617	13.5	.001	0.28	Warning 577, No-warning 598
Cue	45.9	.0001	0.57	Valid 583, Invalid 576, Double-cue 605, No-cue 656	46.9	.0001	0.58	Valid 564, Invalid 560, Double-cue 584, No-cue 639
Flanker	78.2	.0001	0.70	Congruent 577, Incongruent 633	62.5	.0001	0.65	Congruent 564, Incongruent 610

Notes: RT = reaction time; ADHD = Attention Deficit Hyperactivity Disorder; TDC = typically developing children.

for children with ADHD only. For the control group, the absent (mean RT = 545.08 ms) and the present (mean RT = 540.26 ms) warning conditions were not different ( $p = .55$ ). None of the other interactions were significant ( $F < 3$ ).

To evaluate the orienting effect specifically, a “Group  $\times$  Warning  $\times$  Cue  $\times$  Flanker” ANOVA was performed that included only the valid and the invalid trials as spatial cues. This analysis confirmed significant effects for Group— $F(1,34) = 12.24$ ,  $p < .001$ , partial  $\eta^2 = 0.26$ ; Warning— $F(1,34) = 19.31$ ,  $p < .0001$ , partial  $\eta^2 = 0.36$ ; Flanker— $F(1,34) = 70.22$ ,  $p < .0000001$ , partial  $\eta^2 = 0.67$ ; and Group  $\times$  Warning— $F(1,34) = 8.66$ ,  $p < .01$ , partial  $\eta^2 = 0.20$ —interactions. The Cue and all the other interactions were not significant ( $F < 2$ ).

The ANOVAs performed on the orienting and conflict effects did not reveal any significant effects or interactions ( $F < 3$ ).

**Accuracy analysis.** The effect of the Group— $F(1,34) = 4.36$ ,  $p < .05$ , partial  $\eta^2 = 0.11$ —revealed a higher percentage of uncorrected responses in the children with ADHD (mean = 8.51) when compared with typically developing children (mean = 3.31), but this difference was only marginally significant. A significant Flanker effect— $F(1,34) = 28.16$ ,  $p < .00001$ , partial  $\eta^2 = 0.45$ —revealed that there were less incorrect responses in the congruent (mean = 4.28) than in the incongruent trials (mean = 7.53). All other effects or interactions were not significant ( $F < 2$ ).

#### No-Feedback Trials

**Reaction time analysis.** Table 3 reports the means ( $\pm$ SD) for each experimental condition. All main effects were significant (Table 4), and children with ADHD showed slower RTs than controls and faster RTs when the tone was present than when it

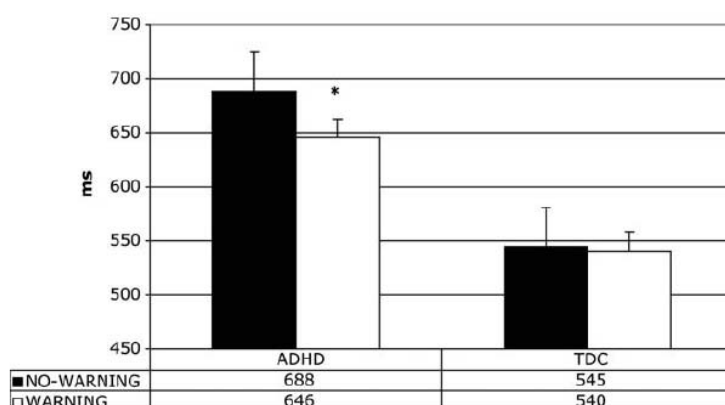


Fig. 3. Mean reaction times in children with ADHD and in typically developing children (TDC) in both absent warning condition (black bars) and present warning condition (white bars) in feedback trials.

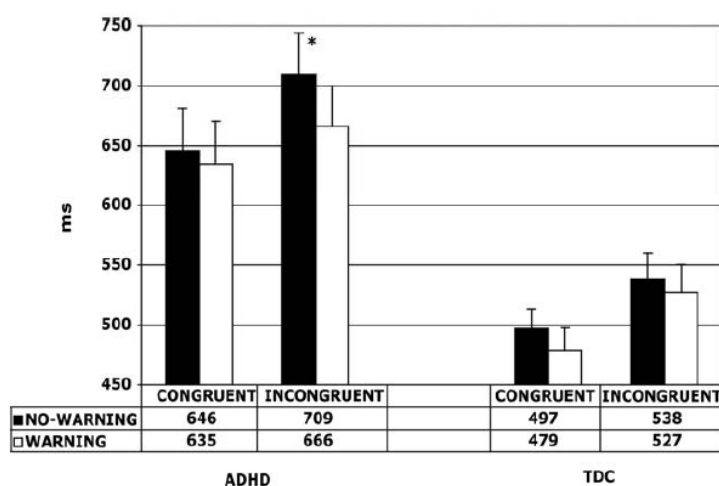


Fig. 4. Mean reaction times in children with ADHD and in typically developing children (TDC) in response to congruent and incongruent flankers in both absent warning condition (black bars) and present warning condition (white bars) in no-feedback trials.

was absent. The Cue effect revealed no difference between valid and invalid trials, but these trials were faster than both the double-cue ( $p < .01$ ) and the no-cue ( $p < .0001$ ) trials. The double-cue and the no-cue trials were also significantly different ( $p < .0001$ ). Furthermore, the Flanker effect showed faster RTs in the congruent trials than in the incongruent trials. The Group  $\times$  Warning  $\times$  Flanker interaction— $F(1,34) = 4.29$ ,  $p < .05$ , partial  $\eta^2 = 0.11$  (Fig. 4)—revealed that the presence of the warning reduced RT in children with ADHD only when they responded to incongruent flanker trials ( $p < .001$ ). The Cue  $\times$  Flanker interaction— $F(3,102) = 2.56$ ,  $p = .06$ , partial  $\eta^2 = 0.07$ —and all other interactions were not significant ( $F < 2$ ).

When considering only valid and invalid trials, the results confirmed the effects observed for Group— $F(1,34) = 18.29$ ,  $p < .0001$ , partial  $\eta^2 = 0.35$ ; Warning— $F(1,34) = 11.09$ ,  $p < .01$ , partial  $\eta^2 = 0.25$ ; Flanker— $F(1,34) = 24.05$ ,  $p < .0001$ , partial  $\eta^2 = 0.41$ ; and Group  $\times$  Cue  $\times$  Flanker— $F(1,34) = 4.96$ ,  $p < .05$ , partial  $\eta^2 = 0.13$  (Fig. 5)—interactions. This analysis revealed that children with ADHD had slower RTs in the valid trials (mean RT = 637.51 ms) than in the invalid trials (mean RT = 606.50 ms;  $p < .01$ ) in the congruent flanker condition only. The Cue effect ( $F < 1$ ), the Cue  $\times$  Flanker interaction,  $F(1,34) = 3.93$ ,  $p = .06$ , partial  $\eta^2 = 0.10$ , and all the other interactions ( $F < 3$ ) were not significant.

There was no significant effect or interaction for the orienting effect ( $F < 2$ ).



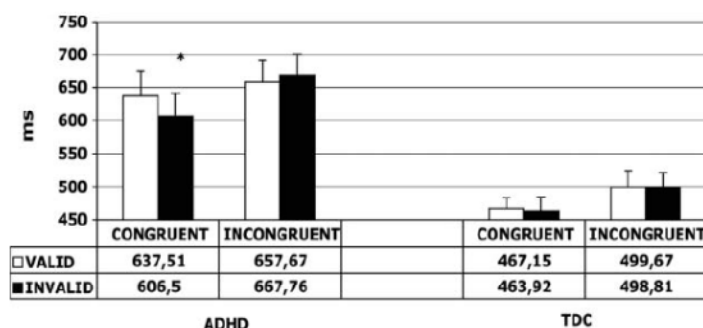


Fig. 5. Mean reaction times in children with ADHD and in typically developing children (TDC) in response to congruent and incongruent flankers in valid (white bars) and invalid (black bars) trials in no-feedback trials.

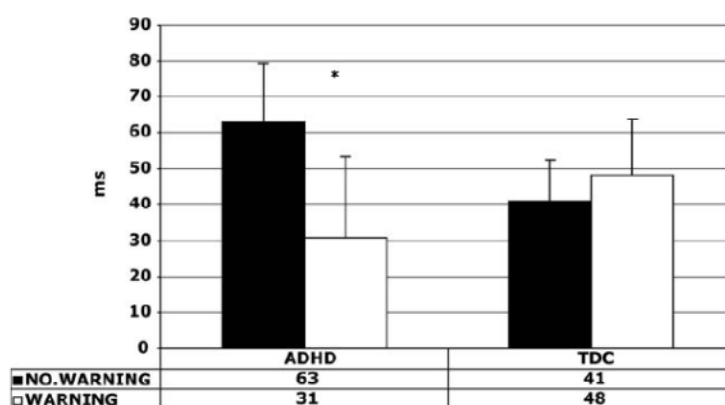


Fig. 6. Conflict effect (RT incongruent flankers – RT congruent flankers) in children with ADHD and in typically developing children (TDC) in both absent warning condition (black bars) and present warning condition (white bars) in no-feedback trials.

With regard to the conflict effect, the Group  $\times$  Warning interaction— $F(1,34) = 4.29$ ,  $p < .05$ , partial  $\eta^2 = 0.11$  (Fig. 6)—revealed that children with ADHD had greater conflict than control in the absent warning condition (mean = 63.18) than in the present warning condition (mean = 31.24,  $p < .05$ ; Fig. 6).

**Accuracy analysis.** An effect of Cue— $F(3,102) = 3.08$ ,  $p < .05$ , partial  $\eta^2 = 0.08$ —revealed a lower percentage of errors in the no-cue trials (mean = 8.56) than in all the other trial conditions (mean valid = 10.75, mean invalid = 10.14, mean double-cue = 10.26,  $p < .05$ ), but this difference was only marginally significant. The Flanker effect— $F(1,34) = 45.75$ ,  $p < .0000001$ , partial  $\eta^2 = 0.57$ —revealed more correct responses in the congruent (mean = 8.06) than in the incongruent trials (mean = 11.80). All of the other effects and interactions were not significant ( $F < 3$ ).

## Discussion

### Attentional Systems in ADHD

The slower functioning and poorer performance of children with ADHD confirm the presence of relevant attentional deficits. Our results are consistent with the hypo-arousal hypothesis (Andreou et al., 2007; Johnson et al., 2007; Konrad et al., 2006). Nevertheless, the alerting property of the warning itself is effective for children with ADHD. In fact, the auditory warning specifically increases alertness (i.e., speeds up RT) in children with ADHD, but not in controls. Such results support the effectiveness of increasing alertness to contrast the sustained attention deficit of children with ADHD (Adólfssdóttir et al., 2008; Booth et al., 2007; Johnson et al., 2008).

However, it is remarkable that the increase in alertness induced by the presence of the warning was effective only when a feedback was present. In other words, this difference cannot be attributed to a general increase in alertness produced by the feedback. In fact, a statistical analysis performed to directly compare the two experiments (not reported) did not reveal any difference in RTs between the experiments or a Group  $\times$  Experiment interaction ( $F < 1$ ). We might conclude that the alerting effect of the auditory warning in children with ADHD is modulated by the presence of the feedback. In fact, a Group by Warning interaction was observed in the feedback trials only (Fig. 3). The role of reinforcement has been widely reviewed by comparing 1,181 children with ADHD and typically developing children (Luman et al., 2005). The authors concluded that reward and response cost have a positive effect on the task performance of both children with ADHD and typically developing children, but they also highlighted that the observed improvement was more prominent in children with ADHD than in typically developing children. Our results seem to be consistent with these conclusions, but our findings also indicated that reinforcement interacts with the alerting system. In fact, reinforcement increases alertness in children with ADHD when it is present, and it affects the other two attentional systems (orienting and executive), which are similar to normally developing children. This modulation of alertness by reinforcements could explain some inconsistent results present in literature (Luman et al., 2005; Wodka et al., 2007).

In the no-feedback trials, the warning improves RT in children with ADHD when they respond to incongruent flanker trials (Fig. 4). It should be noted that children with ADHD need only half the time to resolve an attentional conflict in the presence of the warning (present warning condition:  $RT_{\text{incongruent}} - RT_{\text{congruent}} = 31.24$  ms) when compared with its absence (absent warning condition:  $RT_{\text{incongruent}} - RT_{\text{congruent}} = 63.18$  ms; Fig. 6). This difference is specifically due to the capacity of the warning to reduce the RT in the incongruent condition. This result is of interest for at least two reasons. On the one hand, it suggests that an increase in alertness is able to help children with ADHD resolve attentional conflicts. On the other hand, it indicates that the warning is effective only for incongruent trials. This could suggest that children with ADHD do not have a general deficit in the executive system itself, but an executive deficit specifically related to the low level of alertness. We could argue that the executive impairment found in ADHD can directly depend on the low level of alertness, instead of being an autonomous deficit. Children with ADHD could have an alertness impairment that worsens their performance during a particularly difficult task (incongruent trials). This hypothesis also appears to be supported by the absence of a Group  $\times$  Flanker interaction ( $F < 1$ ). Alternatively, we can assume that the executive system in ADHD is preserved at high levels of alertness and impaired at low level of alertness. In fact, according to Sergeant's hypothesis (Sergeant, 2000, 2005), the executive deficits of ADHD could, at least in part, be explained in terms of an energetic dysfunction.

These results could also explain some of the inconsistent results obtained for executive deficits in children with ADHD. It is important to highlight that all studies evaluating attentional systems using the ANT have not independently manipulated alertness (they have not introduced an auditory warning). Many methodological differences among these studies (Table 1) could have produced uncontrolled variations in alertness, which could partially explain some of these incoherent results.

Attentional conflict resolution in typically developing children tended to take more time in the presence of the warning (48.47 ms) than in the absence of the warning (41.07 ms; Fig. 6). This result is consistent with data observed in adults showing that an increase in alertness induces an interfering effect in conflict solution (Fan et al., 2009).

We did not observe faster RT in the orienting system when the spatial cue was valid compared with when it was invalid. Valid and invalid cues produced attentional benefits in both groups of children. Spatial cues improved alertness, but they have not been able to induce the orienting of attention (valid and invalid cues did not result in different RT). This result is inconsistent with other findings reporting slower RTs when children with ADHD responded to a valid or an invalid cue than to either neutral or no-cue conditions (Dhar, Been, Mindera, & Althaus, 2008; Huang-Pollock, Nigg, & Halperin, 2006; McDonald, Bennett, Chambers, & Castiello, 1999; for a review see Huang-Pollock & Nigg, 2003). However, our data are consistent with Pearson, Yaffee, Loveland, and Norton (1995), who attributed this effect to a decreased flexibility in children with ADHD in orienting attention on a diffuse area of the visual space. In agreement with Huang-Pollock and Nigg (2003), we conclude that children with ADHD could have difficulty in voluntarily spreading their attention across a large area of space (as required by double- or no-cue conditions) while awaiting the target to optimize the detection of a target at any location. The results of our study indicate that this difficulty is also present in typically developing children. We did not observe a validity effect (faster RTs in the valid compared with the invalid trials) in either children with ADHD or typically developing children. This result can be attributed to the type of stimulus onset asynchrony (SOA) used. In fact, Rueda's SOA of 600 ms might induce a facilitation in some children, but an inhibition of return (IOR; slower RTs in valid trials compared with invalid trials) in others (Posner & Cohen, 1984). In accordance with this hypothesis, approximately half of the children showed faster RT when the cue was valid rather than invalid (validity effect), whereas the other half displayed an opposite pattern (IOR effect). Nevertheless, when children with ADHD responded to congruent flankers, an IOR effect was observed, suggesting an impairment in disengaging attention. This result confirms previous observations in children with ADHD performing a Covert Orienting task (Swanson et al., 1991; Wood, Maruff, Levy, Farrow, & Hay, 1999), and it seems to highlight



a difficulty in the endogenous method of orienting (for a review, see Huang-Pollock & Nigg, 2003). Endogenous orienting refers to a voluntary allocation of attentional resources to a spatial location, whereas exogenous orienting is considered reflexive and automatic (Jonides, 1981). It is well known that similar neural networks may mediate endogenous orienting and IOR (Mayer, Dorfinger, Rao, & Seidenberg, 2004). Our results suggest that children with ADHD can have impairments in the voluntary allocation of visuospatial attention, as shown by their difficulty in disengaging attention from an invalid location, whereas automatic orienting to exogenous cues seems to be intact. It is not clear why this IOR effect is observed only in the congruent flanker condition.

The analysis of accuracy confirms a poorer performance in children with ADHD than in typically developing children. It also reveals a significant impairment when incongruent rather than congruent flankers are presented, highlighting a no trade-off accuracy effect. It is important to note that the percentage of errors was not high, but this could be due to the appealing graphic characteristics of the task.

### *Clinical Implications of Results*

The results of this study seem to suggest that a balanced program that includes positive and negative reinforcements and simultaneously produces an increase in auditory alertness may be effective in improving the attention of children with ADHD. Further experiments are needed to decouple the clinical subtypes of ADHD and to determine the effectiveness of different programs of reinforcement. For example, is the random administration of reinforcement equally as effective as a continuous one? Which frequency of reinforcement is more effective? This could be investigated by realizing and assessing a behavioral reinforcement program aimed to promote an increase in alertness. Such a program should involve both parents and teachers.

It might be interesting to examine whether and to what extent a similar program is able to improve all attentional systems or alertness only in children with ADHD.

### **Conclusions**

The two revised versions of ANT appear to effectively assess the efficiency of the three attentional systems, as all main effects were significant. They also highlight impairments in each attentional system for children with ADHD, albeit to a different degree. Alertness appears to be particularly impaired. However, deficits are also observed in the orienting and executive systems. All of the attentional networks seem to be modulated by feedback. In fact, in the feedback trials, no significant difference between ADHD and typically developing children was observed for the orienting or executive networks.

The improved performance in children with ADHD in the warning present condition suggests the effectiveness of increasing alertness in order to counteract the sustained attention deficit of children with ADHD.

Our results also confirm the utility of the ANT in evaluating all the attentional systems and their interactions at the same time. In fact, some specific deficits in children with ADHD with regard to conflict solution and orienting are evident only when analyzing the interactions among the attentional systems.

To the best of our knowledge, this is the first study to simultaneously assess the efficiency and interactions among the attentional systems in children with ADHD by independently manipulating the orienting, alerting, and executive systems. It is also important to note that our participants were drug-naïve children with no major co-morbid disorders except ODD. It should be also noted that only one other study has included drug-naïve children (Konrad et al., 2006). That study recorded the concomitant activation of the neural networks. However, from a behavioral point of view, it also introduced a bias by collecting the RT of children in an unusual condition (during the execution of an fMRI).

Our strong selection criteria for children with ADHD allow us to hypothesize that the observed results may effectively reflect the actual framework of attention in ADHD. On the other hand, this selection is also the source of the primary weakness in our study: the small number of participants. Future studies will address this limitation.

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### **Conflict of Interest**

None declared.

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Il Progetto è realizzato con il contributo, parziale, della Regione Lombardia  
(in attuazione della D.G. sanità n. 3250 del 11/04/2011)  
Capofila Progetto: UONPIA Azienda Ospedaliera “Spedali Civili di Brescia”  
“*Condivisione dei percorsi diagnostico-terapeutici per l’ADHD in Lombardia*”.

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