

Review article

Attention Functions and Deficits in Children

Hazem Alawadli¹, Omayma Afsah², Essam A. A. Elmagd³, Tamer Abou-Elsaad²

¹Phoniatric Unit, ORL Department, Faculty of Medicine, Aswan University, Egypt.

²Phoniatric Unit, ORL Department, Faculty of Medicine, Mansoura University, Egypt.

³ORL Department, Faculty of Medicine, Aswan University, Egypt.

ABSTRACT

Keywords: ; ADHD;
Attention; Attention
disorders; Attention deficit.

***Corresponding Author:**

Hazem Alawadli,

E-mail:

dr.hazemsami@gmail.com

Tel: 00201001184330

Attention is essential for most, if not all, information processing pathway that transforms stimulus input into response output. Attention is comprised of multiple components and is not a unitary construct. Attention disorders are among the most prevalent varieties of childhood disorders and result in adverse long-term outcomes such as antisocial behavior and poor academic performance. Attention Deficit Hyperactive Disorder (ADHD) was the most common cause of attention deficit in children. ADHD may be one of the most common childhood mental health conditions in the world. The cause of most ADHD cases is unknown; however, it is believed to involve interactions between genetic, environmental and psychosocial factors. The purpose of the current review paper was to review the literature about the attention functions and its deficits in children to provide a rational basis for the implementation of appropriate assessment and therapeutic intervention.

INTRODUCTION

Attention may be a fundamental aspect of human behavior and of cognitive functions, like perception, memory, language etc. In other words, attention is important for many, if not all, processing of information pathway that transforms stimulus input into response output. Therefore the process of attention has been the main target of plenty of research [1].

Attention impairment is a core symptom of patients with Attention-deficit/hyperactivity disorder (ADHD). Neuropsychological assessment has revealed that children with ADHD experience difficulties during a sort of functions associated with attention, including selective attention, distractibility, and sustained attention, as compared with healthy children and normative data [2].

ADHD is a common and impairing neuropsychiatric disorder of early onset that's characterized by age-inappropriate hyperactivity, inattentiveness, and impulsivity. Children with ADHD tend to do poorly in class and are in danger for school failure. They typically have difficulties allocating their attention efficiently and, in a minimum of some situations, are more susceptible to distraction. In school, the skills to selectively attend to the teacher, sustain that

attention through a lesson, and inhibit processing of the distracters within the classroom, are critical for learning and school success [3].

The purpose of the current review paper was to review the literature about the attention functions and its deficits in children to provide a rational basis for the implementation of appropriate assessment and therapeutic intervention.

1. Basics of Attention

1.1. Definition:

Attention is usually defined as an individual's ability to concentrate or sustain focus on a task. Historically, attention has been described as a filtering system that sifts through large amounts of information to permit selected information to be perceived [4].

1.2. Components of Attention:

Attention is comprised of multiple components and isn't a unitary construct. A three-system perspective of attention was developed and included the terms orienting, alerting, and target detection. Orienting refers to both overt visual orienting and therefore the initial covert shifting of attention to a location. Alerting denotes the power of the individual to organize and sustain alertness when processing priority information. In target detection the attention system moves from a generalized alert state to a more highly engaged state when locating a visual target [5].

Additional researchers agree with this multi-component perspective of attention, but instead name they name the three elements of attention focus, sustain, and shift. Focus is analogous to target detection mentioned by **Posner and Peterson** [5], as both equate with the ability to pick a target from a display of stimuli. Sustained attention is that the ability to keep up focus over time or vigilance and can be related to alerting. Attention shift refers to the ability to flexibly and adaptively adjust focus and correlates well with the subsystem of orienting [6].

Manly et al. [7] proposed a three-factor model of attention including selective attention, sustained attention, and attention control or switching.

1.3. Neuroanatomy of Attention:

Several studies support the point of view that the attention system of the brain is specialized, localized, and interconnected [8].

Through primate and human lesion studies, the posterior aspect of the parietal lobes, the posterior lateral aspect of the thalamus, and therefore the superior colliculus, located within the inner brain, have been found to be active in coordinating orienting also referred to as attention shift [5]. In additional recent human lesion studies, the process of attention shifting or switching has also been observed within the prefrontal cortex, located anteriorly within the frontal lobes [9].

In cerebral blood flow studies, the anterior cingulate, located just beneath the frontal lobes, was noted to be especially active during target detection [5]. More specifically, the anterior cingulate is believed to mediate response selection and modulate stimulus selection [10].

With reference to vigilance, the right hemisphere and possibly more specifically the right prefrontal cortex appear to be related to the ability to initiate and sustain attention [5]. **Manly et al.** [11] also reported that the ability to sustain attention relies on adequate functioning of the right lobe more recent sustained counting tasks performed with human lesion subjects, not only supported, but added accuracy to the present theory. **Shallice et al.** [12] found that the right

prefrontal cortex and therefore the anterior cingulate do “play key roles in attention,” but rather than controlling sustained attention, the process of initiation or energizing was shown to be a more precise description.

From the neuroanatomical discussion above, it's easy to ascertain the specialization and interconnection of the attention system as processing occurs anteriorly, laterally, and inferiorly throughout the brain. Researchers still notice the differing characteristics of attention that correspond to a variety of separate brain locations [13].

1.4. Stages of Attention Development:

Cooper et al. [14] postulated that the development of attention in children passes through the subsequent stages:

- 1- **Stage 1** (typically 0-1 years): Children at this stage are extremely distractible, the child's attention flits from one object, person or event to a different. Any new event, like someone walking by will immediately distract them.
- 2- **Stage 2** (typically 1-2 years): during which the child can focus on a concrete task of their own choosing, but won't like all intervention by an adult, whether verbal or visual and should appear inflexible. The child attention is single focused and that they attempt to block out all other stimuli so as to concentrate on what they're doing.
- 3- **Stage 3** (typically 2-3 years): Attention is single channeled therein the child cannot attend to auditory and visual stimuli from more than one source at one time. the child find it difficult to concentrate to an adult's direction while he's playing, but is able to shift his whole attention to the speaker then back to the game, with the adult's help.
- 4- **Stage 4** (typically 3-4 years): the child must still alternate his full attention between the speaker and therefore the task, but now does this spontaneously without the adult wanting to focus their attention.
- 5- **Stage 5** (typically 4-5 years): the child's attention is now two channeled, i.e. they understand verbal instructions associated with the task without interrupting their activity to look at the speaker. Their concentration span may still be short but they will be taught in a group.
- 6- **Stage 6** (typically 5-6 years): Auditory, visual and manipulatory channels are fully integrated and attention is well established and sustained. They're gradually ready to exclude unwanted, irrelevant information and concentrate only on essential aspects.

1.5. Attention and Executive Functions:

Executive functions (EFs) were defined as “the ability to keep up an appropriate problem set for attainment of future goals” [15] and include such abilities as components of attention, reasoning, planning, inhibition, set-shifting, interference control, and working memory [16]. EFs are considered to be vital for complex human behavior [17]. Attention problems are widely thought to reflect deficits in executive functions (EFs), a family of cognitive control processes that operate on lower-level processes to control and shape behavior [18]. Many studies documented that children with attention Deficit Hyperactive Disorder (ADHD) exhibit Executive Function Deficits (EFDs). **Pennington and Ozonoff** [16] reported that children with ADHD consistently exhibit worse performance on certain cognitive and EF measures. Despite these consistent data implicating EFDs in ADHD, little or no is understood about the clinical implications of EFDs in children and adolescents with ADHD.

Friedman et al [19] found that attention problems at all age groups significantly predicted individual differences in later Inhibiting, Updating, and intellectual thinking, and that attention problems at a number of the ages also predicted Shifting. Model comparisons indicated that attention problems were differentially related to the three EFs especially, attention problems were more closely related to Inhibiting than to Updating and Shifting. They also found that attention problems were more strongly associated with Inhibiting than to intellectual thinking, which suggests that the link between attention problems and Inhibiting isn't simply because of lower levels of general cognitive ability related to attention problems.

2. Attention Disorders in Children

Deficits in attention processes are attributed to several developmental conditions other than ADHD including acquired or neurological disorders like epilepsy, learning disabilities, depression, Autism, and in children prescribed medical treatments like chemotherapy or epilepsy medication [20]. Additional researchers also include “Traumatic Brain injury, Tourettes syndrome, Insulin Dependent Diabetes, anxiety disorder and Post Traumatic Stress Disorder” as diagnoses that regularly demonstrate attentional differences [13].

2.1. Attention Deficit Hyperactive Disorder (ADHD):

2.1.1. Definition:

ADHD is a psychiatric neurodevelopmental disorder within which there are significant problems of attention, hyperactivity, or acting impulsively that aren't appropriate for an individual's age. It had been claimed that, these symptoms must begin by the age of six to 12 and be present for more than six months for diagnosis to be made [21]. The terminology used to describe the condition has changed over time. **DSM-I (1952)** referred to ADHD as "minimal brain dysfunction". In **DSM-II (1968)**, it had been known as "hyperkinetic reaction of childhood", in **DSM-III (1980)**, it had been named "attention-deficit disorder (ADD) with or without hyperactivity". In 1987 this was changed to ADHD in the **DSM-III-R** and therefore the **DSM-IV** in **1994** split the diagnosis into three subtypes, ADHD inattentive type, ADHD hyperactive-impulsive type and ADHD combined type. These terms are still preserved in **DSM-V** in **2013**.

2.1.2. Prevalence:

ADHD may be one of the most common childhood mental health conditions in the world [22]. The prevalence of ADHD is conservatively estimated as being from 3% to 7% of the school aged children within the United States. Boys with ADHD outnumber girls, but ratio varies significantly from 2:1 to 9:1. Gender differences are less obvious for inattentive type. Boys are more likely to be aggressive and to possess other behavioral problems [23].

In the Arab world, few studies are published on ADHD. However, a systematic review study using the meta-analysis method estimated the prevalence of ADHD across Arab countries. In these countries, the prevalence of ADHD ranged from 7.4% to 14.8%, ranging from 7.8% to 18.3% among boys and 3.5% to 11.4% among girls [24].

2.1.3. Etiology of ADHD:

The cause of most ADHD cases is unknown; however, it's believed to involve interactions between genetic, environmental and psychosocial factors [25].

2.1.3.1. Genetics

Twin studies indicate that 75% of ADHD cases are often inherited from one parent. Siblings of children with ADHD are three to four times more likely to develop the disorder than

siblings of children without the disorder. Genetic factors also are believed to be involved in determining whether or not ADHD persists into adulthood [26].

Typically variety of genes are involved, many of which directly affect dopamine and serotonin systems. These include dopamine transporter, dopamine receptor D4, dopamine beta-hydroxylase, monoamine oxidase A, and Catecholamine-methyl transferase. As regard serotonin, the defect includes, for instance, 5-hydroxytryptamine 2A receptor (5-HT_{2A}), 5-hydroxytryptamine 1B receptor (5-HT_{1B}) [27].

2.1.3.2. **Environmental Factors:**

Alcohol intake during pregnancy can cause fetal alcohol spectrum disorder which may include symptoms almost like ADHD. Exposure to tobacco smoke during pregnancy can cause problems with central nervous system development and may increase the risk of ADHD. A combination of a genetic predisposition with tobacco exposure may explain why some children exposed to tobacco inhalation during pregnancy may develop ADHD and others don't. Children exposed to lead, even low levels, or polychlorinated biphenyls may develop problems which resemble ADHD and fulfill the diagnosis. Exposure to the organophosphate insecticides chlorpyrifos and dialkyl phosphate is related to an increased risk; however, the evidence isn't conclusive [28].

Very low birth weight, premature birth and early adversity also increase the risk as do infections during pregnancy, at birth, and in infancy. These infections include among others: various viruses (measles, varicella, rubella, enterovirus 71) and streptococcal bacterial infection. A minimum of 30% of children with a traumatic brain injury later develop ADHD and about 5% of cases are thanks to brain damage [29].

A small number of children may react negatively to food dyes or preservatives. It's possible that certain coloring may act as a trigger in those that are genetically predisposed. Dietary sugar and therefore the artificial sweetener aspartame appear to possess little to no effect, except possibly in children less than six years aged where sugar may increase inattention [30].

2.1.3.3. **Psychosocial Factors:**

Per social construction theory indicated that it's societies that determine the boundary between normal and abnormal behavior. Members of society: including physicians, parents, and teachers determine which diagnostic criteria are used and, thus, the number of individuals affected [31]. The diagnosis of ADHD can represent family dysfunction or a poor educational system instead of an individual problem [32].

2.1.3.4. **Media Exposure and Attention:**

Studies have examined exposure to media like television and video games in childhood and adolescence as a impending risk factor for subsequent attention disorders. It has been assumed that most TV shows are so exciting that children who frequently watch television have more difficulty paying attention to less exciting tasks (e.g. school work). Others have hypothesized that because most TV programs involve rapid changes in focus, frequent exposure to TV may impair children's abilities to sustain focus on tasks that are not inherently attention-grabbing [33].

2.1.4. **ADHD and Attention Model Theories:**

Attention problems seen in clinical settings have received much attention in psychology [34]. The present conceptualization of ADHD might not directly map onto the construct of attention. Models of attention discussed here are generally focused on the amount and kind of

factors that comprise attention for the population of interest, while models of ADHD tend to be more focused on the contribution of certain cognitive/neuropsychological elements that are likely to account for impairment from the disorder. Attention is comprised of multiple components and isn't a unitary construct [5]. Similarly, a one-process theory of ADHD likely doesn't account for the variability of presentation within and across subtype groups of children with ADHD [35]. Although theories and models of ADHD and attention may appear distinct from the clinical version of ADHD, incorporating these theories into the conceptualization of ADHD may better inform the present understanding, and thus, current assessment practices, of the disorder.

2.1.4.1. **Posner's Contribution to the Theory of Attention:**

Posner and Peterson [5] highlighted that attention was perhaps not one single, nebulous function, but a system of varied brain regions related to specific attention functions. They claimed that separate regions of the brain were responsible for attention functions, which attention functions are become independent from one another. Further, they also proposed three related attention functions including orienting to sensory information, detecting target stimuli, and maintaining vigilance or alertness to task (referred to because the orienting network, the alerting network, and therefore the executive network, respectively). Posner and Peterson's theory of attention continued to broaden understanding within the developing field of attention (**Figure 1**).

Figure 1 near here

2.1.4.2. **Barkley's Theory of ADHD:**

Barkley [37] proposed a theory and model of deficits in behavioral inhibition as the hallmark of ADHD. Barkley noted that the conceptualization consistent with DSM-IV criteria isn't theory-driven, but rather behavior-driven, as evidenced in part by the absence of criteria referencing difficulty in motor development and deficits in executive functioning commonly observed in children with ADHD. He suggested that children with hyperactivity and impulsivity are disparate from children with inattention only, but the behavioral inhibition model doesn't specifically address ADHD predominantly inattentive type. Barkley's model is one among difficulty developing behavioral inhibition, which is partially responsible for the performance of four executive functions: working memory, regulation of affect/motivation, internalization of speech, and reconstitution. Barkley suggested that nonverbal working memory is vital for monitoring ongoing behavior, regulation of affect/motivation is related to the role emotion plays in behavior, internalization is essential in applying rules and appraisal of behavior, and reconstitution is involved within the adjustment of behavior for positive social interactions.

2.1.4.3. **Mirsky and Colleagues' Model of Attention and ADHD:**

Based on years of research on brain injury, **Mirsky et al.** [38] developed a model of attention by factor analyzing data from a series of neuropsychological tasks administered to a large group children and adults. They identified four functions of attention from this analysis including focus/execute, sustain and stabilize, shift, and encode. The focus/execute function is described as devoting attention resources to specific tasks and filtering out extraneous stimuli. The sustain function is explained as vigilance to a task over a major amount of time, during which target stimuli aren't missed, and therefore the stabilize function is described because the variability in reaction time on a sustained attention task. The shift function is explained as the flexibility to move back and forth from one task to a different. Finally, the encode function is related to the concept of working memory and is described as holding information briefly and

manipulating it in some way. From this, they asserted that attention may be a process of multiple functions, and can't be explained by one function alone. Further, they asserted that these functions arise from different, specialized brain regions that structure the attention system within the brain. Damage to any of those regions may cause impairment, but it's possible that the attention system can accommodate some injuries and may supply alternative ways to support various attention functions [38]. They applied their four function model of attention to a group of clinic referred children diagnosed with ADHD and a group of community control children and found that the ADHD group demonstrated impairment within the focus/execute, shift, and sustain and stabilize functions of attention. These attention impairments were explained as a developmental lag particular to children with ADHD, during which these children may eventually get on par with their non-ADHD peers, but that these deficits may put ADHD children at risk for academic difficulty [38]. This differs from the neuropsychological bases of impairment proposed in Barkley's model. It's clear that models of attention and models of ADHD have different conceptualizations; however, both forms of models appear to be relevant for understanding, in part, childhood ADHD.

2.1.4.4. **Manly and Colleagues' Model of Attention:**

More recently, **Manly et al.** [39] offered a three factor model of children's attention that has three components: selective attention, sustained attention, and attention control or switching. These components appear to be independent dimensions of attention instead of an overall factor of attention. This three-factor model of children's attention flowed from an earlier model of adult attention demonstrated by the Test of Everyday Attention [40] for adults. The standardization of the TEA gave its authors a chance to assess three facets of attention (spatial, selective, and sustained). According to **Posner and Peterson** [5], **Manly et al.** found that selective and sustained attention were two separate domains. within the interest of knowing whether a model of adult attention might be applied to children's attention, **Manly et al.** [39] developed the TEA-Ch and explained the character of the three attention factors demonstrated by the TEA-Ch as follows:

I. Selective attention: is that the focus and concentration on a discrete task while filtering out extraneous information.

II. Sustained attention: is that the ability to stay focus and concentration on a low-engaging task over an extended period of time.

III. Attention control/switching: is that the ability to shift focus and concentration between sets of information or to shift or inhibit performance required for a task.

2.1.5. **Assessment of ADHD:**

Appropriate assessment instruments are required to ensure that the evaluation process results in a reliable, accurate, and valid diagnosis. Several behavioral questionnaires for parents and teachers have been developed [41]. Also, objective measures have the potential to enhance and simplify current practice in order to shorten assessment time, increase diagnostic accuracy, reduce delays in treatment, and optimize treatment response. Continuous performance tests (CPTs) are neuropsychological tests that measure the individual's attention and impulsivity in a sustained task, and can be used alongside clinical inquiry as part of the diagnostic procedure [42].

2.1.6. Management of ADHD

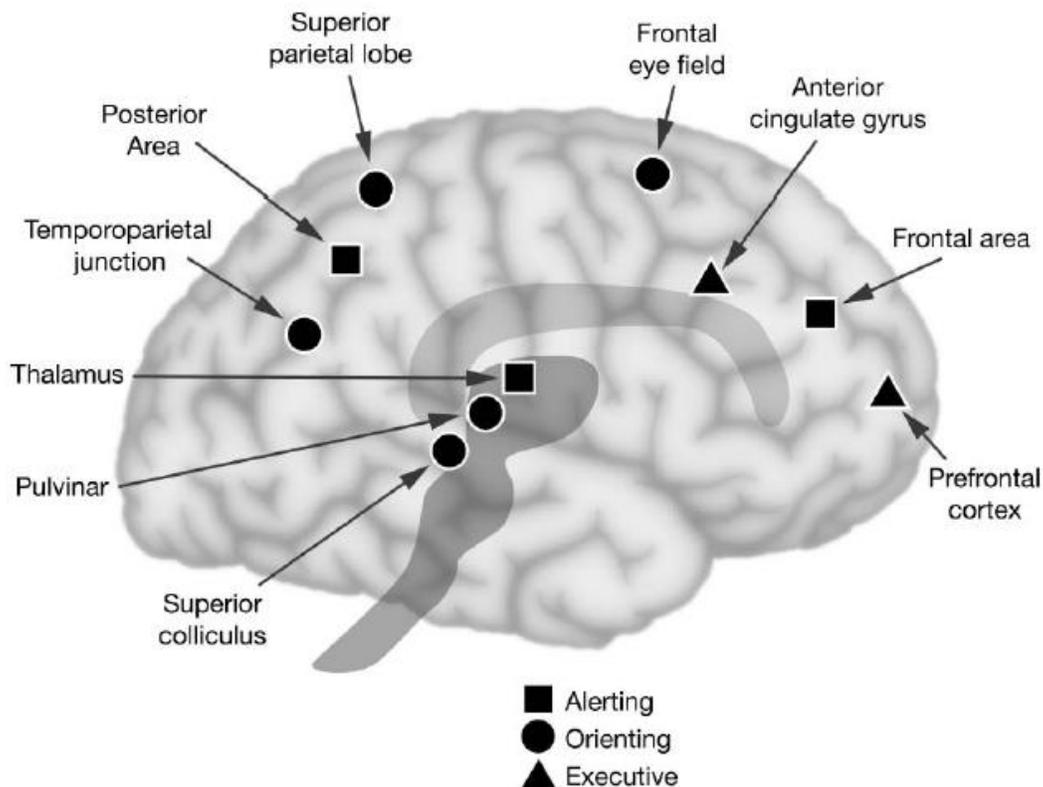
The management of ADHD includes medications or counseling either alone or in combination. While treatment may improve long term outcomes it does not dispose of negative outcomes completely. There is respectable evidence for the use of behavior therapies in ADHD and they are the recommended first line treatment in those who have mild symptoms or are preschool-aged. Psychological therapies used include: behavior therapy, psychoeducational input, cognitive behavioral therapy (CBT), interpersonal psychotherapy, family therapy, parent management training, social skills training, school-based interventions, and neurofeedback. The pharmaceutical treatment used includes alpha-adrenergic agonists, atomoxetine, stimulants, and sometimes antidepressants. They have at least some effect in about 80% of people [43].

2.1.7. Conclusion:

Attention is a vital aspect in perception, memory, language acquisition and learning processes. Attention impairment children tend to do poorly in school and are at risk for school failure. So that, studying of attention functions and deficits are very important to understand its nature and effect in order to provide a rational basis for the implementation of appropriate assessment and therapeutic intervention.

Figure legend:

Figure (1): Anatomy of three attentional networks (orienting network, the alerting network, and the executive network)



References

- [1] Lezak, M.D., Howieson, D.B., & Loring, D.W. *Neuropsychological Assessment* (4th ed.) 2004; New York: Oxford university press.
- [2] Tucha, L., Tucha, O., Walitza, S., Sontag, T. A., Laufkoetter, R., Linder, M., and Lange, K. W. Vigilance and sustained attention in children and adults with ADHD. *J Atten Disord.* 2009; 12: 410-421.
- [3] Gomes H., Duff M., Ramos M., Molholm S., Foxe J., and Halperin J. Auditory selective attention and processing in children with attention-deficit/hyperactivity disorder. *Clin Neurophysiol.* 2012 February; 123(2): 293–302.
- [4] Broadbent, D. E. Perception and communication. 1958; New York, NY: Pergamon Press Inc.
- [5] Posner, M. I. and Peterson, S. E. The attention system of the human brain. *Annual Review of Neuroscience.* 1990; 13: 25-42.
- [6] Mirsky, A. F., Anthony, B. J., Duncan, C. C, Aheran, M. B., and Kellam, S. G. Analysis of the elements of attention: A neuropsychological approach. *Neuropsychology Review.* 1991; 9: 109-145.
- [7] Manly, T., Nammo-Smith, I., Watson, P., Anderson, V., Turner, A., and Robertson, I. H. The differential assessment of children's attention: The test of everyday attention for children (TEA-Ch), normative sample and ADHD performance. *Journal of Child Psychology and Psychiatry.* 2001; 42(8): 1065-1081.
- [8] Cooley, E. L., & Morris, R. D. Attention in children: A neuropsychologically based model for assessment. *Developmental Neuropsychology.* 1990; 6: 239-274.
- [9] Shallice, T., Stuss, D. T., Picton, T. W., Alexander, M. P., and Gillingham, S. Multiple effects of prefrontal lesions on task-switching. *Frontiers in Human Neuroscience.* 2008; 1: 1-11.
- [10] Bush, G., Frazier, J. A., Rauch, S. L., Seidman, L. J., Whalen, P. J., Rosen, B. R., and Biederman, J. Anterior cingulate cortex dysfunction in attention-deficit/hyperactivity disorder revealed by fMRI and the counting stroop. *Biological Psychiatry.* 1999; 45: 1542-1552.
- [11] Manly, T., Robertson, I. H., Galloway, M., and Hawkins, K. The absent mind: Further investigations of sustained attention to response. *Neuropsychologia.* 1998; 37: 661-670.
- [12] Shallice, T., Stuss, D. T., Alexander, M. P., Picton, T. W., and Derkzen, D. The multiple dimensions of sustained attention. *Cortex.* 2007; 44: 794-805.

- [13] Manly, T., Robertson, I. H., Anderson, V., and Nimmo-smith, I. TEA-Ch: The Test of Everyday Attention for Children Manual. 1999; Bury St. Edmunds, UK: Thames Valley Test Company Limited.
- [14] Cooper, J., Moodley, M. and Reynell, J. Helping Language Development: A Developmental Programme for Children with Early Learning Handicaps. 1978; London: Edward Arnold
- [15] Welsh, M. C., and Pennington, B. F. Assessing frontal lobe functioning in children: Views from developmental psychology. *Developmental Neuropsychology*. 1989; 4: 199–230.
- [16] Pennington, B. F., & Ozonoff, S. Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry*. 1996; 37: 51–87.
- [17] Goldberg, E., and Seidman, L. J. Higher cortical functions in normal and in schizophrenia: A selective review. In H. A. Nasrallah (Ed.), *Handbook of schizophrenia*. 1991; Amsterdam: Elsevier.
- [18] Pennington, B. F. *The development of psychopathology*. 2002; New York: Guilford.
- [19] Friedman, N. P., Haberstick, B. C., Willcutt, E. G, Miyake, A., Young, S. E., Corley, R. P., and Hewitt, J. K. Greater Attention Problems During Childhood Predict Poorer Executive Functioning in Late Adolescence. *Association for Psychological Science*. 2007; 18 (10): 893-900.
- [20] Cooley, E. L., & Morris, R. D. Attention in children: A neuropsychologically based model for assessment. *Developmental Neuropsychology*. 1990; 6: 239-274.
- [21] Sroubek, A., Kelly, M., and Li, X. Inattentiveness in attention-deficit/hyperactivity disorder. *Neuroscience Bulletin*. 2013; 29(1): 103–10.
- [22] Faraone, S. V., Sergeant, J., Gillberg, C., and Biederman, J. The worldwide prevalence of ADHD: Is it an American condition? *World Psychiatry*. 2003; 2(2): 104-113.
- [23] Polanczyk, G. and Rohde, A. Epidemiology of attention-deficit/hyperactivity disorder across the lifespan. *Current Opinion in Psychiatry*. 2007; 20: 386-392.
- [24] Farah, L. G., Fayyad, J. A., Eapen, V., Cassir, Y., Salamoun, M. M., Tabet, C. C., and Karam, E. G. ADHD in the Arab World: A review of epidemiologic studies. *Journal of Attention Disorders* 2009; 13: 211-222.
- [25] Thapar, A., Cooper, M., Eyre, O., and Langley, K. What have we learnt about the causes of ADHD? *J Child Psychol Psychiatry*. 2013; 54 (1): 3–16.

- [26] Franke, B., Faraone, S. V., Asherson, P., Buitelaar, J., Bau, C. H., and Ramos-Quiroga, J. A. The genetics of attention deficit/hyperactivity disorder in adults: a review. *Mol Psychiatry*. 2012; 17 (10): 960–87.
- [27] Arcos-Burgos M, Muenke M. Toward a better understanding of ADHD: LPHN3 gene variants and the susceptibility to develop ADHD. *Atten Defic Hyperact Disord*. 2010; 2 (3): 139–47.
- [28] De Cock, M., Maas, Y. G., and De Bor, M. Does perinatal exposure to endocrine disruptors induce autism spectrum and attention deficit hyperactivity disorders?. *Acta Paediatrica* (Review) 2012; 101 (8): 811–8.
- [29] Eme, R. ADHD: integration with pediatric traumatic brain injury. *Expert Rev Neurother*. 2012; 12 (4): 475–83.
- [30] Millichap, J. G., and Yee, M. M. The diet factor in attention-deficit/hyperactivity disorder. *Pediatrics*. 2012; 129 (2): 330–7.
- [31] Kleinman, R. E., Brown, R. T., Cutter, G. R., Dupaul, G. J., and Clydesdale, F. M. A research model for investigating the effects of artificial food colorings on children with ADHD. *Pediatrics*. 2011; 127 (6): e1575–84.
- [32] Elder, T. E. The importance of relative standards in ADHD diagnoses: evidence based on exact birth dates. *J Health Econ* 2010; 29 (5): 641–56.
- [33] Edward L. S., Douglas A. G., Craig A. A. and David A. W. Problems Television and Video Game Exposure and the Development of Attention. *Pediatrics*. 2010; 2:126-214.
- [34] Barkley, R. A. School interventions for attention deficit hyperactivity disorder: Where to from here? *School Psychology Review*. 2007; 36: 279-286.
- [35] Nigg, J. T. Attention, task difficulty, and ADHD. *British Journal of Developmental Psychology*. 2005; 23, 513-516.
- [36] Posner M. I., and Rothbart M. K. Research on Attention Networks as a Model for the Integration of Psychological Science. *Annu. Rev. Psychol*. 2007; 58: 1-23.
- [37] Barkley, R. A. Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*. 1997; 12 (1): 65-94.
- [38] Mirsky, A. F., Pascualvaca, D. M., Duncan, C. C, and French, L. M. A model of attention and its relation to ADHD. *Mental Retardation and Developmental Disabilities*. 1999; 5: 169-176.

- [39] Manly, T., Nammo-Smith, I., Watson, P., Anderson, V., Turner, A., and Robertson, I. H. The differential assessment of children's attention: The test of everyday attention for children (TEA-Ch), normative sample and ADHD performance. *Journal of Child Psychology and Psychiatry*. 2001; 42(8): 1065-1081.
- [40] Robertson, I. H., Ward, A., Ridgeway, V., and Nimmo-Smith, I. Test of Everyday Attention. 1994; Bury St. Edmunds: Thames Valley Test Company.
- [41] Pineda D., Ardila A., and Rosselli M. Neuropsychological and Behavioral Assessment of ADHD in Seven- to Twelve-Year-Old Children: A Discriminant Analysis. *Journal of learning disabilities*. 1999; 32 (2): 159-173.
- [42] Hall C., Valentine A., Groom M., Walker G., Sayal K., Daley D., and Hollis C. The clinical utility of the continuous performance test and objective measures of activity for diagnosing and monitoring ADHD in children: A systematic review. *Eur Child Adolesc Psychiatry*. 2016; 25(7):677-99.
- [43] Dewidar, A. Relation between attention-deficit /hyperactivity disorder test results and communicative deficits in ADHD Egyptian children. Unpublished Master thesis. 2015; Alexandria University, Egypt.