Chapter 3
Executive Dysfunctions in Attention-Deficit Hyperactivity Disorder

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Executive functions (EFs) are the mental control processes that are primarily subserved by the prefrontal area. These functions include processes such as working memory, prioritization, initiation, inhibition allowing to break out maladaptive habits, planning for future goals, decision making and risk evaluation, sequential processing of actions, and flexible adaptation. These processes allow self-regulation by controlling lower cognitive processes such as attention, perception, and motor processes and enable self-directed behaviors for successful routine functioning across the life span. The EFs are, especially, vital in children because these processes allow successful social interaction.

Accordingly, executive dysfunctions represent impaired higher-order cognitive and communicative functions. Executive dysfunctions have been frequently observed in neuro-developmental disorders of autism spectrum disorder, attention-deficit/hyperactivity disorder, phenylketonuria, fetal alcohol syndrome, schizophrenia, obsessive compulsive disorder, and Tourette syndrome. The chapter focuses on attention-deficit/hyperactivity disorder.

Attention-deficit/hyperactivity disorder (ADHD) is a neuro-developmental disorder that is described by a persistent pattern of inattention and/or hyperactivity in an individual which is not seen in healthy individuals at comparable developmental levels. The disorder has been defined in the Diagnostic and Statistical Manual of Mental Disorders-5th edition (DSM-5) as a persistent pattern of inattentive and hyperactive behavior that interferes significantly with functioning of the individual in a variety of contexts including home, school, workplace, social context, etc. (American Psychiatric Association [APA], 2013). It is further explained that the symptoms are classified into two main categories: (i) inattention and (ii) hyperactivity and/or impulsivity. Functional manifestations of inattention are commonly observed in various forms such as disorganization, lack of persistence/perseverance, and problems with maintaining attention which cannot be attributed to a lack of understanding

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A. Ardila et al. (eds.), *Dysexecutive Syndromes*,
https://doi.org/10.1007/978-3-030-25077-5_3

or a challenge. The behavioral manifestations of hyperactivity symptoms are seen in form of unnecessary motor actions, and impulsivity is expressed in quick actions without considering consequences which is mainly derived from a failure in delaying gratification or from a desire for immediate reward.

The problem develops during the neuro-developmental period of childhood but likely to persist for many years or may be for the whole life. The problem is described to be prevalent in approximately 5% children and 2.5% adults around the world (APA, 2013). Other studies have estimated that even two-third (67%) of ADHD children grow up to adulthood period with these symptoms (Ranby et al., 2012). With a particular reference to the symptoms, Sobanski and colleagues have proposed that hyperactivity symptoms incline to decrease, while inattention symptoms tend to increase when an ADHD child grows toward adulthood (Sobanski et al., 2010). In adulthood, individuals with ADHD show symptoms of impulsivity, inattention, and executive deregulation which are manifested in behavioral problems such as impulsive decision-making, trouble in following instructions, high distractibility, difficulty in managing time, working memory impairment, and trouble with quietly involving in leisure activities (Barkley, Murphy, & Fischer, 2008).

The American Psychiatric Association (APA, 2013) contends that during early childhood years, symptoms appear in the form of excessive motor behavior in an ADHD child but due to variability in symptoms, it becomes very difficult to differentiate the symptoms of excessive motor activity from a normal behavior. Arnett, MacDonald, and Pennington (2013) explain that the available screeners are not developmentally sensitive enough to detect any behavioral and cognitive markers of ADHD in preschool years. Therefore, ADHD is quite commonly diagnosed at school when inattention symptoms become apparent and influence school performance. These symptoms tend to stabilize during the early adolescent years. The hyperactivity symptoms in most ADHD individuals become less evident during adolescent or adulthood years but problems of impatience, impulsivity, inattention, and planning difficulty may continue throughout adulthood. This abnormality is relatively stable but some individuals may develop antisocial behavior during adolescence. Prevalence of ADHD is more common in males compared to females with a ratio of 2:1 in children. Females with ADHD commonly show inattention symptoms of ADHD as primary features (APA, 2013).

3.1 Executive Dysfunctions Associated with ADHD

Broadly, the literature describes general cognitive deficits such as deficits in attention, memory, perception, and executive functions in individuals with ADHD (Arnett et al., 2013). More specifically, impairment in executive functions has been considered to be clearly associated with ADHD symptoms. Several theories spotlight the role of executive function deficits in individuals with ADHD (Barkley, 1997; Berger & Posner, 2000; Pennington & Ozonoff, 1996). As executive functions encompass a range of higher regulatory abilities including attention and planning, flexible think-

ing, ability to use feedback, ability to generate and implement strategies which are critical for goal achievement and successful adaptation in social and academic context, so executive dysfunctions in these regulatory mechanisms can lead to poor adaptation and behavioral and emotional problems (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001).

Earlier studies have described that these individuals show deficits on several EF measures (Barkley, 1997; Doyle, 2006; Rapport, Chung, Shore, & Isaacs, 2001); however, deficits on inhibitory control measures and inability to inhibit distractions are among the most consistent findings (see for a review Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005; Wodka et al., 2007). Accordingly, based on Barkley's theory of executive dysfunctions in ADHD, it was found that ADHD combined type was clearly associated with executive dysfunctions but no evidence for executive dysfunctions could be found for ADHD inattentive type (Barkley, 1997). Contrarily, a review of differences in executive dysfunctions in ADHD types proposed that ADHD combined type was strongly associated with inhibition difficulties, while the inattentive type was associated with disorganized and lazy behavior (Milich, Balentine, & Lynam, 2001). Similarly, Willcutt et al. (2005) argued that symptoms of ADHD were connected to executive control disorder manifested mainly in inhibitory difficulties in working memory and planning.

Particularly, the research highlights the role of impaired inhibitory control and working memory processes in ADHD symptomology (Doyle, 2006; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Nigg, 2000). Two competing views describe the primacy of inhibition or working memory in ADHD. One view proposed by Barkley (1997) describes that deficit in inhibitory control mechanisms including inhibiting an automatic/well-learned response, discontinuing an ongoing response, and interference control are the primary cognitive impairments central to ADHD symptoms. These primary deficits in inhibitory processes explain secondary deficiencies in working memory system and associated functions. The second view proposes working memory impairment as a "core" deficit in ADHD (Kofler, Rapport, Bolden, & Altro, 2008; Rapport et al., 2001) and inhibition deficits as the downstream products of this core deficit. They explain that a stimulus must reach the working memory system before a response can be inhibited. However, Nigg (2001) contends that although executive inhibitory responses are clearly impaired in ADHD individuals, the concept of inhibition in ADHD should be refined to differentiate between inhibition of executive control and inhibition of motivational control. To Nigg, ADHD symptoms are more likely to be the effect of executive inhibitory control deficits, particularly, of executive motor inhibition deficits in the case of combined type ADHD.

Critically, Gargaro, Rinehart, Bradshaw, Tonge, and Sheppard (2011) have argued that inhibition difficulties are not the only cognitive deficiencies in individuals with ADHD. Johnson and colleagues have compared an ADHD group, a high functioning autism group, and a control group on Sustained Attention to Response Task on fixed and random order presentations. The individuals with ADHD compared to high functioning autism group and normal controls have shown clear deficits of sustained attention as assessed by commission and omission errors as well as greater response

time variability. The researchers also explain that impaired arousal and top-down control processes are indicative of involvement of sub-cortical arousal systems and attentional networks in the ADHD pathology (Johnson et al., 2007). Barkley (2006) extends that less activation of behavioral inhibition mechanisms, particularly related to poor interference control may cause problems with sustaining attention.

Furthermore, in a meta-analysis review, Willcutt and colleagues have reported that ADHD individuals compared to controls show deficits on EF measures of planning, working memory (spatial and verbal), vigilance, and inhibition (Willcutt et al., 2005). Moreover, Arnett et al. (2013) have contended that these individuals show marked difficulty in abstracting ideas and anticipating consequences of their actions which may explain their increased impulsivity levels. Additionally, the ADHD group has been reported to display weaker iconic memory compared to normal controls at 50 and 100 ms presentation of visual symbols (Ahmadi et al., 2013).

3.2 Executive Dysfunctions and Functioning of Individual with ADHD

It is suggested that deficits in executive functions, emotional regulation, and inhibitory control mechanisms may explain emotional, behavioral, and academic problems in ADHD individuals (Schoemaker et al., 2012; Sobanski et al., 2010). Executive functions are top-down control mechanisms which regulate cognitions, emotions, and behaviors. Impairment in these regulatory abilities has important cognitive, behavioral, emotional, and social consequences for individuals with ADHD. These individuals are at a higher risk of failure in schools, prone to developing emotional and behavioral problems, and face difficulties in forming and maintaining social relationships. Evidence shows that ADHD children show compromised academic performance in forms of poor grades and lower scores on achievement tests compared to their healthy counterparts (Frazier, Youngstrom, Glutting, & Watkins, 2007). Additionally, other school problems such as higher use of counseling services at schools, a higher dropout rate, and grade retention are also reported frequently in these children (DuPaul et al., 2004; Loe & Feldman, 2007; Molina et al., 2009). It is proposed that inattention symptoms compared to hyperactivity symptoms are more strongly associated with academic problems. Evidence also supports attention problems to be the predictors of poor academic performance in ADHD children (Galera, Melchior, Chastang, Bouvard, & Fombonne, 2009; Merrell & Tymms, 2001) and in children who are below the diagnostic threshold (Breslau et al., 2009; Currie & Stabile, 2006). With particular reference to specific EF deficits, previous researchers have reported working memory to be a correlate of poor school performance and learning problems in children with and without ADHD (Alloway & Alloway, 2010; Alloway, Elliott, & Place, 2010). The role of working memory seems important in classroom assignments, remembering rules and instructions, complex task management, etc. (Alloway, Gathercole, & Elliott, 2010). In the school context, academic

difficulties are generally associated with symptoms of inattention while problems in peer interaction are associated with impulsivity and hyperactivity.

In addition to cognitive and academic difficulties, individuals with ADHD face problems in modulating affective conditions and understanding emotional stimuli. Barkley (2006) defines emotional self-regulation as a set of mechanisms that activates appropriate modular emotional reactions to stimuli. Emotional problems of ADHD individuals can be attributed to dysfunctions in the inhibitory control mechanisms. Poor emotional regulation can result in either excessive emotional reactions to certain stimuli, in poor emotional empathy, or in a decreased ability to regulate emotional states. This, in turn, may lead to increased levels of irritability, frustration, or aggressiveness. These individuals show emotional symptoms of emotional instability, emotional liability, extreme emotional reactivity, and low frustration tolerance (Martel & Nigg, 2006; Sobanski et al., 2010). Their family and peer relationships are characterized by frequent discords and negative interactions in the form of peer rejection and neglect. The deficits in emotional regulation are said to be the product of impaired executive control processes (Sobanski et al., 2010). To Barkley (2006), although problems with emotional regulation are not included in the diagnostic criteria of ADHD, yet, these are fundamental features of the disorder.

Evidence from several studies indicates that children with ADHD demonstrate difficulties with self-regulation and behavioral problems due to alterations in sustained attention and inhibitory control (Puentes-Rozo, Barceló-Martínez, & Pineda, 2008). As children with ADHD are unable to put adequate efforts on tasks requiring sustained attention, so they are perceived as lazy, irresponsible, and non-cooperative individuals. In adults with ADHD, the symptoms predict poor occupational success in terms of output, attendance, achievements, and promotions as well as a higher likelihood of unemployment and interpersonal problems (APA, 2013). Other behavioral problems associated with EF deficiencies in individuals with ADHD are problems with financial decisions and deadlines, motivational instability, losing enthusiasm, a lack of self-monitoring, not completing tasks, etc. Additionally, they face problems with taking initiative, inhibiting automatic responses, planning, setting priorities and goals, and time management (Wasserstein & Lynn, 2001). Overall, these individuals complete less schooling and achieve lower grades and poor vocational success. In case of severe symptoms, the individual's academic, occupational, familial, and social adaptability is significantly impaired.

3.3 Neurobiology of Attention-Deficit/Hyperactivity Disorder

Previous literature suggests ADHD symptoms to be correlated with impaired performance on inhibition measures as well as on associated neuropsychological measures assessing sustained attention, delayed gratification, insight, organization and planning, time management, and response time (e.g., Johnson et al., 2007; Willcutt et al.,

2005). To Barkley (2006), these findings suggest the contribution of multioperational location systems of brain which are likely to be mediated by specific neurotransmitter. Currently, researchers have started neurophysiological and neuroimaging assessments of individuals with ADHD alongside the neuropsychological assessment and cognitive testing. Although the related research is still in its infancy, the neural correlates of executive dysfunctions in ADHD have been started to be discovered by structural and functional neuroimaging studies.

A growing body of neuroimaging studies link abnormalities in brain regions related to prefrontal cortex with compromised performance on tasks assessing executive functions (Moore, Schettler, Killiany, Rosene, & Moss, 2012; Petrides, 2000; Ravizza & Ciranni, 2002; Stern et al., 2000). More specifically, neuroimaging studies provide evidence for the link of inhibitory deficits with deficient neural activity within the fronto-striatal and fronto-parietal circuits in ADHD individuals (Arnsten, 2009; De La Fuente, Xia, Branch, & Li, 2013; Dickstein, Bannon, Castellanos, & Milham, 2006; Hart, Radua, Nakao, Mataix-Cols, & Rubia, 2013; Seidman, Valera, & Makris, 2005). Due to PFC changes, these individuals suffer from executive control disorders generally expressed in inhibitory difficulties (Willcutt et al., 2005). Also, evidence from meta-analysis studies describes a consistent pattern of hypoactivation in frontal areas of the brain in ADHD compared with controls individuals (Cortese et al., 2012; Dickstein et al., 2006). Due to PFC changes, these individuals suffer from executive control disorders generally expressing in inhibitory difficulties (Willcutt et al., 2005).

Neuroimaging studies have tried to recognize the pathophysiology of ADHD by assessing the abnormal structural and functional patterns in brain areas that are typically involved in attention, executive functions, response inhibition, working memory, motor control, and emotional regulations. Accordingly, several studies describe the involvement of brain structures in the frontal cortex including prefrontal cortex, basal ganglia, and posterior cortex in ADHD symptoms (Arnsten & Li, 2005). Additionally, a review study by Cortese and colleagues, based on 55 MRI studies, has shown bilaterally reduced size of putamen, reduced volumes of right anterior frontal cortex and left caudate nucleus in individuals with ADHD (Cortese et al., 2012). Also, the review has reported that children with ADHD show lower measurements on cerebellum activity throughout their childhood and adolescent years. In addition, they reported a slightly reduced right PFC and a more symmetrical left PFC in individuals with ADHD that may likely affect higher regulatory cognitive abilities of inhibition, planning, sustained focus, and organization of information (Cortese et al., 2012; Doyle, 2006).

The findings from studies conducted on samples of children with ADHD compared to controls have revealed a consistent pattern of hypoactivation in frontal brain areas involved in executive functioning and attention including fronto-parietal areas and ventral attentional network. Further studies with children samples have shown hypoactivation in somatomotor networks (Cortese et al., 2012). Furthermore, findings from electroencephalogram studies indicate the link of ADHD symptoms with brain activity, supporting the increased activity level in the EEG (Boutros, Fraenkel, & Feingold, 2005). A different activity pattern in electrophysiological measurements

have been shown in children with ADHD compared to controls on exposure to emotional stimuli (Singhal et al., 2012), on inhibitory tasks (Bruckmann et al., 2012), and in reaction time in cognitive testing (McLoughlin, Palmer, Rijsdijk, & Makeig, 2014).

3.4 Biochemical Correlates of ADHD

Research on the neurobiological basis of ADHD shows dysfunctional biochemical processes particularly related to dopamine, noradrenaline, and serotonin which may cause impairments in cognitive processes (Volkow et al., 2011). Accordingly, dopamine transmission theory of ADHD proposes dysfunctional dopaminergic activation in two brain regions: first, hypoactivation in anterior cingulate cortical regions causing cognitive deficits, and second, hyper-activation in sub-cortical regions particularly in caudate nucleus leading to excessive motor activation (Castellanos, 1997). Additionally, Arnsten, Steere, and Hunt (1996) propose abnormal activation of noradrenaline in two brain regions: (i) underactivation in cortical dorsolateral prefrontal region which relates to core working memory deficits; and (ii) overactivation of the subcortical region of locus coeruleus relating to over-alertness in ADHD.

3.5 Treatment

Treatment for ADHD symptoms can help reduce the symptoms and improve attention and concentration.

3.5.1 Multimodal Treatment of ADHD

Although pharmacotherapy has been proven helpful and successful for treating ADHD symptoms, it should be combined with psychotherapy for more effectiveness and better results. Therefore, a multimodal treatment plan is better recommended for ADHD treatment. Medical treatment may include medications that may help the patient to concentrate better, remain calm, and be less impulsive. The stimulant drugs such as methylphenidate may work by activating brain areas relation to attention. Other drugs such as Atomoxetine, a noredrenaline reuptake inhibitor may increase noradrenaline in brain areas which in turn can also help concentrate and reduce impulsive behavior.

Alongside medical treatment, different psychological therapies can be useful for relieving the ADHD symptoms. Among these are included: psycho-education, cognitive behavior treatment, social skills training, and parent education and training. Many of these psychotherapies have been implemented previously with effective

outcomes in ADHD patients. For example, implementing cognitive behavior therapy, coaching, and behavior therapy including parent training in clinical setting or at home and in school setting have been shown to be effective (e.g., Knight, Rooney, & Chronis-Tuscano, 2008; Pelham & Fabiano, 2008). Furthermore, interventions aimed at promoting attention skills such as "the Pay Attention! Program" has also shown positive improvement in attention (Tamm et al., 2010). Empirical evidence suggests that interventions aiming at alleviating not only the ADHD symptoms but also the patient's day to day functioning using multimodal treatments including medical and psychosocial, prove more effective than the medical treatment alone (Reeves & Anthony, 2009).

Psycho-education may aid in educating the individual with ADHD about the symptoms of the disease and its effects on daily life. It can also educate the individual to become an active part of the treatment agency for effective results. *Behavior therapy* commonly targets behavior problems. By using reward system, it controls disorganized and impulsive behavior. For improvement, first list down the behavior problems and identify good behaviors needed to be introduced, set rewards, implement step by step, but consistently. The therapy can include teachers and parents in the treatment plan to make them learn how to plan and structure behaviors and activities and to motivate and admire the child on improvements. *Cognitive behavior therapy* may help the patients identify, analyze, and change maladaptive thinking patterns with more rational and adaptive thinking pattern which may, in turn, result in adaptive behavior. *Social skills training* should be used in combination with other psychological and pharmacological treatment plans. It involves teaching the child how to behave in different social contexts using adaptive social skills. It may involve role-playing and modeling techniques. *Parent education and training* should be an integral part of the psychosocial intervention. It involves educating parents about the disease and its effect on daily functioning. It also includes tailoring parents to learn specific ways of talking to and playing, involving, and working with the child with ADHD. This may help the child in focusing attention and reducing impulsive and disorganized behavior.

Other possible treatments may include healthy diet and use of food supplements. Individuals with ADHD are recommended to use a healthy and a balanced diet. Deficiencies in certain nutritious dietary elements can worsen ADHD symptoms. Protein-rich and healthy food helps in making neurotransmitters and is important for brain health, so it is a protective factor against ADHD symptoms. Also, these individual are recommended to avoid processed and junk food as well as fizzy drinks. Some studies have suggested that certain food supplements such as omega 3 and omega 6 fatty acids as well as zinc, iron, and magnesium can supplement nutrient deficiencies and help in making neurotransmitter involved in attention and concentration (Konofal, Lecendreux, Arnulf, & Mouren, 2004; Johnson, Ostlund, Fransson, Kadesjö, & Gillberg, 2009).

3.5.2 Executive Functioning Interventions

A new line of research suggests that interventions aiming at specific executive dysfunctions may also help in relieving ADHD symptoms. Recently, empirical evidence proposes that executive functions can be promoted in children and adolescents through specific activities as well as by using EF training. Researchers recommend that EF improvement in children with ADHD can help reduce impulsive behaviors and improve attention and memory which may, in turn, promote better self and emotional regulation (Diamond, Barnett, Thomas, & Munro, 2007). Menezes and colleagues contend that instead of cognitive training, ecological EF intervention should be focused for more generalization and improvement in EF-related daily functioning in these individuals (Menezes, Dias, Trevisan, Carreiro, & Seabra, 2015).

3.6 Comorbid Disorders with ADHD

Clinical research and related discussion in DSM-5 describes the presence of several comorbid disorders in individuals with ADHD (APA, 2013). The ADHD is described to be extremely comorbid disorder with more than 60–70% of individual with ADHD showing symptoms of other psychiatric disorders (Cherkasova, Sulla, Dalena, Pondé, & Hechtman, 2013; Spencer, 2006).

3.6.1 Comorbid Disorders in Childhood

Behavioral problems are the most frequent comorbidities in children with ADHD. Among these are oppositional defiant disorders (ODD) and conduct disorder (CD). Other comorbid conditions include autism spectrum disorder and specific learning disabilities.

3.6.1.1 Oppositional Defiant Disorder

The comorbidity of the ODD is described to be in about 50% of the combined type and in about 25% of the inattentive type ADHD children (APA, 2013). In such comorbid cases, children are psychologically and emotionally more impaired. During early school years, comorbidity of ADHD and oppositional defiant behavioral problems likely predispose children in bullying involvement. However, effective treatments are likely to decrease the risk of further psychological problems in adulthood years such as anxiety, depression, or substance abuse. For the optimal treatment of individuals with comorbid ADHD and ODD, it is better recommended to combine pharmacotherapy with psychosocial treatment particularly behavior therapy. Behav-

ior therapy should incorporate treatment plans targeting time management, response inhibition training, setting rules, and establishing goals. For ODD, the treatment usually involves the introduction of rules and aims to re-establish generational limits.

3.6.1.2 Conduct Disorder

The occurrence of conduct disorder is reported in about a quarter of combined-type ADHD children and adolescents (APA, 2013). Prevalence of conduct disorder has been reported to be in about 2–9% of the population, and its prevalence is particularly higher in individuals from low socioeconomic status (Baker, 2013). Comorbidity of CD with ADHD also adds to the severity of the cognitive and behavioral problems. Children with comorbidity of ADHD and CD symptoms are reported to have a poor prognosis and are vulnerable to develop disorders including substance abuse and antisocial personality disorder in adulthood (Barkley, Fischer, Smallish, & Fletcher, 2004). The comorbidity of both can be explained by the shared risk factor hypothesis which states that each of the two disorders is a risk as well as the precursor of developing the other disorder (Shachar & Tannock, 1995). With comorbid symptoms of the two disorders, medications for ADHD symptoms in combination with drugs for aggressive symptoms are recommended. However, it is strongly recommended to use psychosocial intervention along with pharmacotherapy in a multimodal approach for more effective outcomes.

3.6.1.3 Autism Spectrum Disorder

Estimates suggest that two-third of individuals with ADHD manifest symptoms of autism (Davis & Kollins, 2012). Therefore, neurological studies seek to identify common neurological substrates that may link with similarities in neuropsychological profiles in individuals with both disorders or with comorbid conditions. Empirical evidence shows that patients with autism as well ADHD patients are impaired on working memory and cognitive flexibility, while impairment on inhibitory control differentiates between two with ADHD combined-type patients showing inhibition deficiencies compared to autistic patients (Paloscia et al., 2013).

3.6.1.4 Learning Disorder

Specific learning disorders are also reported to be a comorbid diagnosis in ADHD children. It is estimated that nearly one-fourth of ADHD children (20–25%) also meet the diagnostic criteria for any learning disorder (Pliszka, 2000). However, the adverse effects of ADHD symptoms on academic output persist even after controlling the effects of learning disorders (Currie & Stabile, 2006) and behavior problems (Giannopulu, Escolano, Cusin, Citeau, & Dellatolas, 2008).

3.6.2 Comorbidities with ADHD in Adulthood

Comorbidities of psychiatric disorders with ADHD also differ depending on the life stage. For example, as discussed above, children with ADHD are more likely to share symptoms of ODD, CD, autism, and learning disorder. However, adults with ADHD are more likely to develop any anxiety disorder, substance abuse, antisocial or any other personality disorder, or social phobia, but children are more likely to have comorbid oppositional disorder and separation anxiety (Biederman et al., 1993).

It has been reported that adults with ADHD have co-occurring diagnosis of anxiety in 47%, any mood disorder in 38%, impulse control in 20%, and substance use disorders in 15% of patients (Kessler et al., 2006). However, sometimes symptoms of ADHD are obscured due to more robust symptoms of the comorbid disorder or the vice versa. Few of these comorbid symptoms may be the outcome of the impact of ADHD symptoms. For example, anxiety may be the aftereffect of poor academic outcome due to ADHD. On the other side, depression may share the common environmental risk factor with ADHD (Faraone & Biederman, 1997).

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