1. INTRODUCTION

This chapter examines the electrophysiological correlates of attention deficit hyperactivity disorder (ADHD) in children. As a growing number of children are diagnosed with this disorder, researchers are increasingly interested in ADHD and the cognitive processes of affected children. According to Schroeder and Gordon (1), ADHD is the most frequently diagnosed childhood disorder, with a prevalence of 3–7% among school-aged children (2). Although ADHD affects adults as well, this chapter focuses on the occurrence of this disorder in children. The sections below present brief diagnostic criteria of ADHD, according to the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) (2), provide an explanation of the diagnostic subtypes of the disorder, highlight comorbidity and subtype issues relating to event-related potentials (ERPs), examine electrophysiological findings regarding attention in children with the disorder, and investigate electrophysiological correlates of the disorder in relation to drug interventions. (For additional in-depth reviews of ADHD and ERPs, see refs. 3 and 4).

2. DIAGNOSIS

According to the DSM-IV (2), ADHD is characterized by the existence of inattention and/or hyperactivity–impulsivity. Inattention is characterized by carelessness, inattention to detail, distractibility, failure to listen, problems with organization, forgetfulness, and inability to follow directions. The behaviors that characterize hyperactivity are fidgeting; failure to remain seated in situations in which it is expected; inappropriate movement, such as running or climbing; difficulty staying quiet when it is expected; and excessive talking. Impulsivity is characterized by difficulty in being patient and frequently interrupting others during conversations or activities. Such patterns of behavior must occur at a level that is maladaptive for at least 6 mo and the individual must exhibit at least one of the distinguishing categories of behavior: inattention or hyperactivity–impulsivity. To be diagnosed with ADHD, the child must display at least six of the nine specified symptoms of inattention or hyperactivity–impulsivity. The symptoms of ADHD must begin before 7 yr of age and interfere in at least two settings, such as school and home. In addition, for a diagnosis of ADHD, the presenting symptoms cannot be explained by
the existence of schizophrenia, pervasive developmental disorder, psychotic disorder, or any other mental disorder (2).

3. SUBTYPES OF ADHD

When diagnosing ADHD, there are three subtypes that can be specified based on the main symptoms that the child has displayed over the previous 6-mo period. Although some children may exhibit indicators of all the characteristic behaviors (inattentiveness, hyperactivity, and impulsivity), the subtypes allow for the designation of the principal behaviors that cause impairment in the child’s life (2). The subtypes are: combined type, predominantly inattentive type, and predominantly hyperactive–impulsive type. When designating a predominant subtype, it is important to consider the symptom presentation and the number of symptoms present for the previous 6 mo. For example, if six or more symptoms of inattention have been present along with fewer than six symptoms of hyperactivity–impulsivity, ADHD predominantly inattentive type is diagnosed, and vice versa for ADHD, predominantly hyperactive–impulsive type. In the case of ADHD, combined type, the most commonly diagnosed subtype in children and adolescent populations, more than six symptoms of inattention and hyperactivity–impulsivity must have occurred over the prior 6-mo period for this characterization to apply (2).

4. USE OF ERPs IN STUDY OF ADHD

ADHD is a disorder that may cause significant impairment in a child’s life, resulting in academic, social, and interpersonal difficulties. Previous research has focused on the performance of children diagnosed with ADHD on behavioral tasks assessing attention regulation, memory, and inhibition that are thought to relate to these difficulties. As a result, researchers are increasingly interested in the corresponding brain responses that accompany such behaviors. One procedure used to determine the brain mechanisms utilized by children with ADHD is the use of the ERP. The ERP recorded from the scalp is a synchronized portion of the ongoing electroencephalographic pattern. It is usually represented as a complex waveform made of positive- and negative-going peaks. Such waveforms are thought to indicate changes in brain electrical activity over time as reflected by changes in the amplitude or height of the wave as well as the latency or timing of the peaks (5). What distinguishes the evoked potential from the more traditional electroencephalogram (EEG) measure is that the ERP is time-locked to the onset of some event in the person’s environment. The ongoing EEG activity reflects a wide range of neural activity related to a plethora of neural and body self-regulating systems, as well as various sensory and cognitive functions ongoing in the brain at that time. The ERP, on the other hand, because of this time-locked feature, has been shown more likely to reflect both general and specific aspects of the evoking stimulus and the individual’s perceptions and decisions regarding that stimulus. It is this time-locking feature that enables researchers to pinpoint, with some degree of certainty, portions of the electrical response that occurred while a person’s attention was focused on a discrete event.

The ERP is not an exact and completely stable pattern reflecting only those discrete neural events directly related to the evoking stimulus, the task, or the response to such an event, which begins at levels well below that of the cortex as the stimulus information is transformed by the sensory systems and progresses through the brainstem, into the midbrain, and on upward into the higher brain centers. Such signals that originate within the brain must travel through a variety of tissues of different densities, conductivity, and composition (e.g., neurons,