

by E. Mark Mahone, PhD, ABPP

**A**DHD IS THE MOST PREVALENT PSYCHIATRIC DISORDER OF CHILDHOOD, affecting nearly ten percent of all US children ages 4-17 years (Pastor et al., 2015). Despite tremendous advances in identification and treatment in the past fifty years, children with ADHD often struggle both socially and academically, even when treated.

By the age of four, as many as forty percent of children have sufficient problems with attention to be of concern to parents, preschool teachers, and daycare providers. In young children, however, how does one know if a child who is active or distractible has a disorder, such as ADHD, or whether the behaviors are simply within the range of what is considered “normal”? Unlike other developmental conditions, like autism spectrum disorders, in which children often present with behaviors considered atypical under any circumstances (such as abnormal language use, stereotypic behaviors), those behaviors observed as part of the diagnostic criteria for ADHD (high activity, impulsiveness, distractibility) are observed in nearly all typically developing children who do not have ADHD.

Is there something unique or different about children diagnosed with ADHD that makes their behaviors easily distinguishable from those seen in otherwise typically developing youngsters? Unfortunately, the answer is no. What distinguishes children with the *diagnosis* of ADHD from those children who simply have *symptoms* of ADHD? Essentially, it is the frequency, duration, and intensity of the behaviors—not the nature of the symptoms themselves. Thus, accurate characterization of ADHD as a categorical diagnostic condition is challenging.

Clinicians and researchers face at least three critical challenges when studying and treating children with ADHD:

- **Diagnosis.** At an individual level, the ADHD is defined and diagnosed based on symptoms (behaviors), rather than by physical characteristics, lab tests, or pathophysiology.
- **Heterogeneity.** Even within the diagnosis of ADHD, there is considerable variability of presentation and considerable change in symptoms over the course of childhood.

# ADHD as a Dimensional Disorder



sional

- **Comorbidity.** More often than not, in the course of their lifetime, children with ADHD manifest some other condition in addition to the ADHD. If only the ADHD is addressed, outcomes tend to be poor.

### What constitutes a “disorder” anyway?

In current clinical practice, ADHD is conceptualized as a *neurodevelopmental disorder*. Having a “disorder” implies that one has some type of personal limitation that produces a disadvantage when attempting to function in society. In other words, simply having the symptoms does not constitute a disorder. It is only when the symptoms cause the individual to have difficulty doing the things that are needed in everyday life that a diagnosis is made. As a neurodevelopmental disorder, ADHD is presumed to be the result of an early occurring “difference” in the developing brain. The developmental course of ADHD usually begins in early childhood, and lasts (to some degree) throughout the lifetime. Thus, from a biological perspective, “normal” development of the brain is altered, resulting in reorganization that is less efficient for the purposes of cognitive and behavioral functioning.

Using this definition, behaviors are best understood within the context of the environment, personal factors, and available supports. A disorder is thought to occur when there is a mismatch between the individual’s own biologically based assets and the demands (social, academic) imposed within his/her environment. In neurodevelopmental disorders such as ADHD, this mismatch can change over time, such that symptoms are “time referenced,” where some functional difficulties can be observed early on in life, but the full range of concerns may not manifest until later, even though the biological basis of the condition is present earlier.

Practically, the functional disability observed in children with ADHD is highly variable. Diagnosis of ADHD is often not clearly categorical (that is, yes or no), but rather, more like the diagnosis hypertension (occurring on a spectrum). For clinicians, teachers, and parents, it is critical to use a lifespan perspective to understand the dynamic developmental course, and changing needs of the individual. ADHD “unfolds” over time, and individuals may cross in and out of the strict diagnostic threshold.

### Current diagnostic schemes

There are two primary approaches to classification of neurodevelopmental disorders—one emphasizing *behavior*, and the other emphasizing *neurology* (Mahone, Slomine, & Zabel, 2016). ADHD is an example of a behaviorally defined condition. The problem with the behavioral scheme, however, is that it does not address etiology.



To better understand neurodevelopmental disorders, researchers search for pathophysiological correlates of behaviorally defined conditions (examples include ADHD, dyslexia, autism spectrum disorders), and for behavioral phenotypes of genetic or neurologically defined disorders (Down syndrome, Fragile X syndrome, Neurofibromatosis Type 1, for example).

The diagnostic criteria for ADHD recently changed with the publication of the fifth edition of the *Diagnostic and Statistical Manual for Mental Disorders* or DSM-5 (American Psychiatric Association, 2013). Although the DSM-5 retained most of the diagnostic criteria for ADHD that were previously contained in the DSM-IV-TR (APA, 2000), three important changes were introduced, that may ultimately serve to increase rates of diagnosis:

- The age of onset criterion was increased from age 7 to age 12 years.
- The symptoms of inattention and/or hyperactivity-impulsivity are now required to be merely present (rather than causing “impairment”).
- There is a provision for adult diagnosis (ages 17 and older), requiring only five (rather than six) symptoms of inattention and/or hyperactivity-impulsivity.

### ADHD as a developmental delay

There is emerging evidence from the research literature that ADHD may be best conceptualized as a “delay” in brain maturation, rather than as a discrete categorical entity reflecting a deviation from typical development (Shaw et al., 2007).

**Modern conceptualizations of neurodevelopmental disorders such as ADHD are moving away from categorical diagnoses to recognizing the condition as a spectrum disorder.**

As our brains develop, the thickness of the cerebral cortex increases steadily (but at different rates) across different parts of the brain, ultimately reaching plateau around adolescence, and eventually decreasing as result of “pruning” of brain cells or neurons. Neuroscientists consider this plateau and ultimate “thinning” of the cerebral cortex to represent the time when that part of the brain is considered to have matured.

Interestingly, in school-aged children, this rate of cortical thinning occurs more slowly in children with ADHD than in those without the condition. Moreover, the rate of thinning is actually proportional to the level of symptoms observed across all children, such that those with the most rapid thinning have the fewest ADHD symptoms, those with slightly delayed cortical thinning have slightly more ADHD symptoms, while those with the slowest (most delayed) cortical thinning have the most severe ADHD symptoms (Shaw et al., 2011). A similar pattern has been observed in preschool-aged children (ages 4-5 years), such that the size of the caudate nucleus (a subcortical brain structure related to cognitive and motor control) is directly proportional to the number and severity of hyperactive/impulsive symptoms (Mahone et al., 2011).

These patterns have prompted researchers to argue that ADHD should be considered *dimensionally* (rather than categorically), with the “disorder” lying at the extreme with regard to symptoms and cognitive impairments (Shaw et al., 2011).

### **RDoC and dimensions of behavior**

Even with these recent changes in the DSM-5, the psychiatric conceptualization of ADHD remains categorical (that is, you have it or you don't). Recognizing that this diagnostic scheme doesn't map directly onto the known neurobiological correlates of the behaviors, the National Institutes of Mental Health introduced an alternate method for conceptualizing mental disorders *dimensionally* as brain disorders. The purpose of the new scheme, referred to as the *Research Domain Criteria*, or RDoC, was to develop, for research purposes, new ways of classifying mental disorders based on behavioral dimensions and neurobiological measures (Insel et al., 2010).

The scheme de-emphasizes categorical diagnoses, and instead measures functions that may occur (to some degree) across many types of disorders. Examples of RDoC-based dimensional functions relevant to individuals with ADHD include those framed as *positive valence systems* (reward-related processing, for example), *negative valence systems* (emotional lability, for example) *cognitive*

*systems* (vigilant attention, cognitive control, reaction time variability), and *arousal systems* (wakefulness). Though developed for research purposes, the ultimate goal of the RDoC framework is to inform clinical practice. For example, using the RDoC scheme, researchers using neuroimaging studies may identify a type of attentional control (behavioral) associated with abnormalities in brain connectivity (pathophysiology) that responds better to non-stimulant medications than to stimulant medications (treatment).

Dimensional frameworks such as RDoC may be better suited to study the whole child, without the constraints of categorical diagnoses, especially for those children whose behaviors and cognitive skill patterns fall subthreshold for diagnosis. Because 67 percent of children with ADHD have some co-existing condition (Larson et al., 2011), dimensional frameworks may also better address the complicating factor of comorbidities.

In summary, modern conceptualizations of neurodevelopmental disorders such as ADHD are moving away from categorical diagnoses to recognizing the condition as a spectrum disorder. The developmental course is often lifelong, necessitating a family practice approach to consultation and intervention, in which caregivers provide assistance in different contexts and in different formats throughout the life of the individual with the condition. In doing so, it is essential for the clinician to recognize how changing environmental demands interact with the individual's neurobiology, and how these interactions may change over the individual's lifetime. 🧠

---

**E. Mark Mahone, PhD, ABPP**, is a child neuropsychologist, research scientist, and the director of the department of neuropsychology at the Kennedy Krieger Institute. He is also professor of psychiatry and behavioral sciences at the Johns Hopkins University School of Medicine. Dr. Mahone's research focuses on brain-behavior relationships in children with neurodevelopmental disorders as well as the development and validation (using neurobehavioral assessment and neuroimaging) of assessment methods to better characterize neurobehavioral development (and ultimately biomarkers) of these disorders.

---

### **REFERENCES**

- Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Pine, D., Quinn, K., Sanislow, C., & Wang, P. (2010). Research Domain Criteria (RDoC): Toward a new classification framework for research on mental disorders. *American Journal of Psychiatry*, *167*, 348-351.
- Larson et al. (2011). Patterns of comorbidity, functioning, and service use for US children with ADHD. *Pediatrics*, *127*, 462-7.
- Mahone, E. M., Crocetti, D., Ranta, M. E., Gaddis, A., Cataldo, M., Slifer, K. J., Denckla, M. B., & Mostofsky, S. H. (2011). A preliminary neuroimaging study of preschool children with ADHD. *The Clinical Neuropsychologist*, *25*(6), 1009-1028
- Mahone E.M., Slomine, B.S., & Zabel, T.A. (in press). Genetic and neurodevelopmental disorders. In J. Morgan & J. Ricker (Eds.). *Textbook of Clinical Neuropsychology* (2nd ed.). New York: Psychology Press.
- Pastor, P., Reuben, C., Duran, C., Hawkins, L. (2015). Association between diagnosed ADHD and selected characteristics among children aged 4-17 years: United States, 2011-2013. *NCHS Data Brief*, *201*, 1-8.
- Shaw, P., Eckstrand, K., Sharp, W., Blumenthal, J., Lerch, J.P., Greenstein, D., Clasen, L., Evans, A., Giedd, J., & Rapoport, J.L. (2007). Attention-deficit/hyperactivity disorder is characterized by a delay in cortical maturation. *Proceedings of the National Academy of Sciences*, *104*, 19649-19654
- Shaw, P., Gilliam, M., Liverpool, M., Weddle, C., Malek, M., Sharp, W., ... Giedd, J. (2011). Cortical development in typically developing children with symptoms of hyperactivity and impulsivity: Support for a dimensional view of attention deficit hyperactivity disorder. *The American Journal of Psychiatry*, *168*, 143-151.