

## WOODBURN PEDIATRIC CLINIC

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### ADHD

ADHD is a common condition, affecting up to 8 – 10% of the population. It has an important impact upon the affected child's functioning in school, at home, and in social settings. It causes the child to struggle with meeting those expectations that are often taken for granted in other children. It can easily create a situation where the child's repeated failures to be successful undermine his (or her) self-confidence, self-esteem and motivation. It makes the child particularly vulnerable to ill-informed negative judgments: "He's lazy", "He's not trying hard enough". And, sadly, some of these children begin to internalize these negative pronouncements and carry with them the sense that they are just not as good as other kids. Since no effort they can muster will bring success, they give up. Or worse, they seek out anti-social behaviors.

In children, ADHD is characterized primarily problems along two parameters:

- Poor attentional focus: paying attention to the right thing, with the right intensity, for the right amount of time, and then shifting focus to the next appropriate subject with the right intensity for the right amount of time.
- Problems with overactivity and impulsive control.

Other commonly observed characteristics include:

- Unpredictable performance.
- Pervasiveness of symptoms. These features must be pervasive, present in multiple settings. They are present at home, at school, in the family, with friends, in the car, watching TV, going to the mall, playing outdoors, everywhere. And they must cause impairment in the child's functioning.

Current practice is to distinguish 3 types of ADHD:

- Inattentive
- Hyperactive / impulsive
- Combined

This division may be artificial. There are different degrees of impulsive and hyperactive behavior seen. Even in children with a high level of hyperactivity, this component commonly diminishes around the time of puberty, although a sense of restlessness often persists.

ADHD is a congenital, hereditary, neurologic condition.

Congenital: Symptoms must appear in childhood, and can often be traced back to the child's first few years. In some cases --- where there are strong behavioral supports or when the child is blessed with strong compensatory abilities --- significant impairment may not occur until the increased demands later in life. But to confirm the diagnosis of ADHD, symptoms should have been present before age 12.

Hereditary: ADHD is one of the most strongly inherited medical conditions that we know. There are a couple of non-hereditary factors that have been described --- for example, maternal smoking during pregnancy and severe prematurity --- but the large majority of cases have a strong familial basis. It is unusual to have a child with ADHD and not have the same condition in other family members.

Neurologic: ADHD is clearly a brain-based condition. It is a neurophysiologic and neurochemical difference in brain function.

What ADHD is not: It is not a disorder, but rather, a difference in how the brain processes information. These differences can create lifelong challenges, but the same rules apply to someone with ADHD as apply to everyone else. If you are going to be successful in life, you must identify and develop your strengths, and you must find ways of overcoming or circumventing your weaknesses --- just like every other person on this planet!

We are beginning to understand the biologic basis of ADHD. One might think of the brain as having two sets of functions. One set is the work stations of the brain, the areas assigned to specific cognitive and motor functions. Children with ADHD generally have normal work stations of the brain. They have the same abilities, the same strengths and weaknesses as any other group of children. The second part of the brain is the "control section". It is this part that:

- Determines which activities to pursue and which to suppress.
- Determines how hard to work and how long to work.
- Suppresses impulses that would interfere with the selected activity.

We now have good physiologic data from studies of adults and children that those parts of the brain that we know to be the control sections function in the ADHD brain at a very low level of physiologic activity---essentially the same level that most people's brains function at when we're asleep.

As we understand this, it becomes clear why we treat ADHD the way we do and why that treatment is so successful. We treat ADHD with stimulant medication. With many of our particularly hyperactive, impulsive children, this is intuitively about the dumbest thing we could do. But it works. And it works not because---as we used to believe---the brain is abnormal and the medication has a paradoxical effect. It works because the brain is normal and the medication works exactly as expected---as a stimulant. Specifically, it stimulates the control sections, it wakes up the brain and puts the child back in control of his own brain.

This is such an important topic that we should talk about it also in another way, from a neurochemical perspective. The human brain is an amazingly complex organ. There are approximately 100 billion cells in the human brain, each with thousands (up to 100,000) of connections to other cells. The brain is constantly communicating with itself. How does it do that?

The end of each nerve cell is separated from the next nerve cell by a tiny gap, called a synapse. In each nerve ending there are tiny packets of chemicals, collectively called "neurotransmitters", (and there are dozens of different neurotransmitters in the human brain, each with a particular function, each having specific localizations in the brain). When a nerve impulse reaches the end of the nerve, it causes the release of this chemical into the synapse. When that chemical reaches the next nerve, it will make that nerve do something --- it may make that nerve fire an impulse and carry on the message, it may block that nerve from firing an impulse, or it may change the nerve in some way. After that, the chemical is released back into the synapse where the original nerve has a mechanism to suck it back up and then re-use it.

The two neurotransmitters in ADHD are dopamine and norepinephrine. We have good evidence that, in the ADHD brain, these specific chemicals are present, but in reduced amounts. As a result, with ordinary messages, there may not be enough of the chemical to conduct the message. If the message is highly interesting, the impulses may be repeated so fast that the chemical builds up in the synapse, and now there is transmission. This is why an ADHD child can play video games for hours, but even a few minutes of homework seems like torture.

The action of stimulant medication for ADHD is to block the re-uptake of the chemical from the synapse. Now, when the child is medicated, with an ordinary message, there may not be enough chemical to transmit the message, but what is there stays there. When the next message comes along, there is another little burst of chemical into the synapse. After a while, the amount in the synapse is sufficient that messages are conveyed. From that point forward, until the medicine wears off, brain function is normalized. Once the medicine is gone, you are back to your usual self, no better and no worse --- except that whatever you learned in the interim you retain.

The two critical factors---attentional focus and impulse control---are the primary symptoms of ADHD. The DSM IV criteria that define ADHD, and the rating scales that are derived from them, look only at these two factors. When we look at the outcomes of ADHD in adolescents and adults, we define the persistence of ADHD by whether or not the patient continues to demonstrate a sufficient degree of attentional dysfunction and impulsiveness to qualify for the diagnosis. These symptoms may diminish somewhat with maturity and with developing compensatory strengths. (As a consequence, there is a lower reported incidence of ADHD in the adult population than in childhood.)

Attentional focus and impulse control are only a portion of the full picture of ADHD. As we learn more about the outcomes of people who have struggled with ADHD in childhood---whether or not they were diagnosed as children---we are beginning to see

that these two features are not the only functional deficits they have. There are other psychological functions that become increasingly important as we move through childhood and into adolescence and then adult life. These other executive functions are also impaired to a greater or lesser degree in most people with ADHD. They include:

- Organizing.
- Prioritizing.
- Planning.
- Task initiation.
- Task completion.
- Working memory.
- Mood modulation.
- Metacognition.

It is the impact of deficits in these areas that may cause the greatest difficulties in school, work and home function as the individual progresses through life.

Problems with organization are seen when there is an apparently random approach to managing the spatial or temporal features of one's life. A problem with spatial organization may manifest as having frequent problems finding your car keys, your shoes, the carton of milk you are sure that you bought yesterday. Things may be put away, but not always in the same place, and often with not much thought to efficient retrieval. Time organization may be impaired, so that the time necessary to complete a task is often flagrantly misjudged. This results in being chronically behind schedule, often being late for appointments, having to work much longer than anticipated due to having taken on more responsibilities than could be efficiently fulfilled in the time allotted. Paperwork can be a disaster zone, with missing or misplaced important papers, or conversely, holding onto papers long after they have any conceivable use.

Planning may be inefficient. There may be over-scheduling, with promises made that are impossible to keep. Plans may not take into account predictable difficulties.

Prioritizing has its own unique manifestation in ADHD. Most people prioritize based on importance. The most important task is done first, then the next most important, and so on. In ADHD, priority is often based upon interest and excitement. The less interesting--but often important--tasks are continually postponed, so that doing your homework, doing your chores, or in adults, cleaning the house, finishing that project due at work, etc., are left until it is crisis time and the excitement of dealing with crisis helps to propel you through it.

Getting started on tasks can be difficult, especially tasks that are large or somewhat complex. There is a problem with breaking complicated projects into manageable parts, leading to a sense of overwhelm and procrastination. Energies are diverted to some other, more easily accomplished or more enjoyable task.

Projects that are started are worked on as long as the novelty and excitement are present. By the end, when it is down to the final few steps of finishing and cleaning up,

the interest and enthusiasm is gone, and it's off to something more stimulating. "A hundred projects started, none completed."

Working memory can be impaired. This limits how much data you can keep in mind as you're working on it. This can lead to difficulties in remembering the sequence of steps in a project or a series of things that need to be accomplished. You may go to the store for milk, eggs, cereal and a magazine---and only remember the magazine. Reading comprehension appears to be a problem because information on one page is not retained long enough to integrate it with the next page.

Mood modulation is particularly important. Many people with ADHD will respond impulsively to an emotion before they take the time to process that emotion in order to express it in a way appropriate to the situation. As a consequence, they may be seen as volatile or unpredictable; they may appear to have a problem with anger management.

Metacognition is the ability to self-monitor and modify your behavior. Many people with ADHD have difficulty with this, so that they are unable to read the subtle non-verbal messages that are such an important part of ordinary interactions. They may have difficulty with rapidly incorporating new information that may change the direction of their plans.

Some remarkable research from the NIMH (published 11/07) has shed some interesting light on these executive function deficits in ADHD. We have known for some time that much of the executive function in the brain is conducted by the pre-frontal cortex, particularly the right pre-frontal cortex. This study looked at the maturation of the brain in a group of over 400 children, half typically developing children and the other half diagnosed with ADHD. Beginning at age 5 – 8, the researchers did sequential *f*.MRI studies on both groups of children. They looked at 40,000 separate sites on the cortex, measuring the thickness at each point, this being an indicator of cortical maturation. In the typical children, they found that, by the age of 5 – 8, a small area of the occipital cortex was already mature, the rest of the cortex quite immature. Gradually, over the next 10 to 15 years, there was a wave of maturation, moving from back to front, and filling in last over the right pre-frontal cortex. This process was complete by the early 20's. This is exactly what was expected from numerous prior studies of normal cognitive development

All of our systems are based on an understanding of this process. Our legal system is based on this. If you're 18 and do a crime, you go to jail. If you're 17 and do the same crime, you go to into the juvenile system. It is assumed that you do not yet have the ability to self-regulate and self-monitor, and we give you a less severe consequence. If you're 16 and pass a test, we give you a license to pilot a 2000 pound piece of steel through the streets with the expectation that you have sufficient self-control that you won't kill yourself or anyone else.

Our educational system is based on this. By middle school, we have expectations of our students with regard to their ability to organize and keep track of their work, to be responsible for assignments. With each advancing grade, there is an incremental increase in our expectations.

When the same studies were done in the children with ADHD, the researchers saw exactly the same sequence of brain development, exactly the same pattern---except that everything was delayed by 2 – 5 years.

In other words, as children enter middle and high school, with all of the new challenges of organization and self-regulation, the ADHD youngster may be competing with his peers with a brain that is a few years younger. A 9<sup>th</sup> grader may be just as intelligent as his peers, just as academically capable, but he may be struggling with executive function abilities that would be seen in a typical 5<sup>th</sup> or 6<sup>th</sup> grader. There are not many 5<sup>th</sup> graders who will succeed in high school.

As an additional factor, we know from studies of ADHD adults---long after neurologic development is complete---that they continue to struggle with a variety of executive function activities.

The work of Russell Barkley and others have begun to identify differences in development of the ADHD brain beginning in infancy. There is a delay in the appearance of several key developmental steps that are critical for the emergence of self-regulation, of modifying our behavior to improve our long-term outcome.

The first of these is the ability to delay, to put a gap of time between some stimulus in our environment and how we respond to it. This “gap” allows us to modify how we will respond, allows us to have some control over our response. (When this is weak, we see more impulsive behaviors.)

The next of these so-called “instrumental, self-directed” abilities to develop is visual working memory (also called non-verbal working memory). It is the ability to visualize past experiences and to use that information to modify how you will respond to a similar experience. In a sense, it is re-viewing the past (that is, hindsight) to modify the future (foresight) --- that is, to develop mental processes that include a subjective sense of time. (When this is weak, we see difficulties of time management, of organizing our activities over time. There may be difficulty remembering to do things a particular time, difficulties following a series of instructions.)

Verbal working memory, the ability to talk to ourselves, is next to develop. In the young child, beginning around age 2 to 3, they talk out loud. Gradually, this self-talk becomes internalized and remains as “the voice in our head” that we all have. We use this to control our behavior, for self-direction and instruction, for self-management. It is important for silent reading and for reading comprehension. (When this internalization is delayed, there is excessive talking, less verbal reflection before speaking, difficulties following rules and instructions.)

Next comes emotional working memory, the ability to control and modulate our emotions. When this is weak, we see more volatile emotions, an all-or-nothing quality to our emotions. (When emotional control is weak, it impacts our motivations, our drive. There is more dependence on environmental controls because internal motivation is weak.)

Finally, there is the sense of “mental play”. These are the mental processes involved in analyzing behavior and synthesizing different options, of mentally considering different plans to pick the one that will work best for you. (Weakness in this area affects planning and problem-solving. It affects verbal fluency, a difficulty in putting together various parts of speech to accurately convey a thought.)

There is increasing evidence that all these functions are delayed in their development in ADHD children. They appear, but a little later than they do in typical children, and when they do appear, they have less strength to control behavior.

So now, when we look at what ADHD really is, we see that our usual definition is not really accurate:

ADHD is a delay in the development, and relative weakness of, self-regulation.

It is a delay in the development, and relative weakness of, executive functions.

And ultimately, it is a delay in the development, and relative weakness of, frontal lobe function.

Our existing definition --- involving attention, impulse control and hyperactivity --- is really the special case of what executive function weakness looks like in a primary school-age child. If you're in 2<sup>nd</sup> grade, the expectation is that you will sit quietly in your seat, pay attention and get your work done.

As we grow up, there are whole new sets of demands for good executive function, and these present new challenges for those with ADHD.

Success in school, especially as one moves beyond the primary grades, is based not only on academic ability, but to a substantial degree upon organizational abilities. In this regard, our ADHD youngsters are functioning at a substantial competitive disadvantage. This is not to say that they are doomed because their brains are developing more slowly---rather, to be successful, they need to develop systems of organization, with appropriate accountability to compensate for their executive function weaknesses.

### **Co-morbidity**

Most people with ADHD have additional areas of emotional or neurophysiologic difficulties. These problems are not qualitatively different from those seen in the non-ADHD population, but they are much more frequent among people with ADHD:

- Learning disabilities: from 12 – 60% (or higher, if more subtle problems are counted)
- Anxiety: 20 – 35% of children; even more common in ADHD adults, 25 – 40%
- Depression: 10 – 30% in children, up to 45 – 50% of adults with ADHD. It is important to try to distinguish between depression in an ADHD patient and demoralization, which is a very common consequence of knowing in your heart that you are capable, but never having things work out the way you would like.
- Bipolar disorder: 10 – 20% by early adulthood
- Social deficits (social anxiety disorder, Asperger’s syndrome)
- Tic disorders: up to 7%
- Oppositional Defiant Disorder: 30 – 65%
- Conduct Disorder: 10 – 25% of children and adolescents.
- Substance use disorder: 2 to 3 times more common in adolescents who are not treated compared to those that remain on medication.

Management of the child with ADHD must take into account the co-morbidity as well. For the ADHD child to effectively manage the challenges of home and school responsibilities, each condition must be addressed and mastered.

## **TREATMENT**

There are three aspects of treatment.

- 1) The first is de-mystify the condition, recognizing that ADHD is better thought of as a “variation of normal”---a different way of processing information---than as a “disorder”. This diagnosis has a life long significance. Regret and mourning are not unusual responses to diagnosis.
- 2) Medication is the mainstay of treatment. It is important to be familiar with the medication options, along with expected benefits and side effects.
- 3) Behavioral management. The goal is to begin to help the child develop organizational skills and self-regulation.

Medications are effective in almost all cases to help reduce the primary symptoms of ADHD: inattention and impulse control. Technically, we do not treat ADHD, we treat the impairment that comes from ADHD.

There are three classes of medication which are primary treatments of ADHD, two of these are stimulants and the 3<sup>rd</sup> is a non-stimulant medication. The stimulants are available in a variety of strengths and a variety of durations of action.

The two stimulant classes are:

- Methylphenidate (Ritalin, Concerta, Metadate, Focalin, Daytrana patch).
- Amphetamines: Adderall, Adderall-XR, Dexedrine, Vyvance.
- The third class is Strattera, a non-stimulant medication. While this can be an extremely useful medication, it takes longer to reach its full effect and may be a little less potent than the stimulants.



For reasons that probably have to do with the genetic variability of ADHD, about 40 – 50% of children with ADHD will respond well to either class of stimulant medication. About 20 – 30% clearly do much better with amphetamines, and about 15 – 20% clearly do much better with methylphenidate. Only a very small percentage will fail to respond to an appropriate dose of at least one or the other class of stimulants.

**Side effects of all stimulants are the same:**

- When you initially start a stimulant, you may have a mild headache or mild abdominal pain. When these do occur, they are mild, only last a few days, and can be treated symptomatically if necessary.
- Loss of appetite.
- Difficulty with sleep initiation (N.B. Many children with ADHD have trouble slowing down their thoughts enough to fall asleep; stimulant medication late in the day may actually assist sleep initiation.)
- Tics: may be secondary to the medication, or may be the first indication that the ADHD is co-morbid with Tourette’s syndrome.
- Irritability or moodiness: often seen as a rebound phenomena if the medication level is dropping too fast at the end of its effective period.
- Over-focus (“zombie-like”): generally a sign of an excessive dose.
- Recent claims that certain stimulants (Adderall-XR) were associated with sudden cardiac death have not been substantiated.

The characteristics of ADHD typically make life more difficult for children, and may also make adult life more challenging. But it is important to recognize that the same traits that can be so challenging may also serve as the basis of success:

<b>Inattention to detail:</b>	Capable of seeing the big picture
<b>Distractibility:</b>	Hyper observant, rich imagination
<b>Impulsiveness:</b>	Capable of quick responses
<b>Hyperactivity:</b>	High energy level
<b>Easily bored:</b>	Capacity for innovation
<b>Hyperfocus:</b>	Large capacity to concentrate

**Creative, good in crisis, resilient, energetic, enthusiastic, able to think on their feet**  
**Loves challenges, loves to interact with others.**

ADHD children are dynamic, creative, imaginative, delightful children. They are also challenging, frustrating and fragile. The challenge to us---me, as a physician, and you, as parents---is to guide them to explore and exploit their full potential without destroying their ego.