The ADHD Brain Is Wired Differently

The more we "see" the ADHD brain with neuroimaging, the more we understand how it works. Read this in-depth analysis to learn about the latest discoveries and the most current research on the ADHD brain.

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https://www.additudemag.com/current-research-on-adhd-breakdown-of-the-adhd-brain/

Treating ADHD: What Really Works Best?

"Just tell me one thing so I can get this straight: How much of treating ADHD is medications, and how much is everything else? Is it 50-50? 80-20? Give me a number, so I can wrap my mind around it." Alex wanted Oren Mason, M.D., a family physician in Grand Rapids, Michigan, to cut to the chase. Alex's ADHD treatment plan was complex. He was overwhelmed by the recommendations to exercise daily, hire a coach, listen to some ADHD audio books, get more sleep, and start some supplements. The idea of medication sounded promising to him, but the trials needed to find the right dose of the right medication could take months.

"How much bang for the buck do these treatments give?" is a fair question. People with ADHD have already tried dozens of strategies to improve attention and efficiency that, over time, fizzled out.

On one hand, if non-medication therapies were going to successfully treat Alex's ADHD, they would have done that. He had worked with tutors, therapists, and dieticians, and read self-help books, but he still had inattention and self-control issues. Medication response can be remarkable, but it isn't the whole story. Physicians can't prescribe pills and assume a patient's ADHD will get better.

Many doctors lack personal experience with ADHD, and don't understand how much more rigorous the treatment is than the oft-heard "just pop a pill." Investigators define successful treatment in scientifically accurate terms such as "a 40 percent or better reduction of investigator-rated DSM-V symptomatology, along with a CGI-I score of at least +2."

Patients, bless them, don't talk like that. They tend to have goals for successful treatment, such as "get more organized," "study," "work to my potential," and "be more thoughtful" or "be less frustrated with my children." These goals are hard to express in numbers. They have an "It's hard to describe, but I'll know it when I see it" endpoint.

Alex wasn't asking Dr. Mason to quote studies, just to help him reach some of his goals. Dr. Mason was about to say "50-50," to emphasize that the effects of medication and non-medication therapies are both important, but what came out was, “They’re both essential. It’s 100-100. Neither of them matters much without the other.”

Researchers have worked on that question and have tried to give us more accurate numbers, even if they aren’t exact. It turns out that you get about 30 percent of what researchers call “the potential response” with medications alone, and about the same from evidence-based non-medication therapies. Using only one therapy alone misses 70 percent of the potential improvement. In other words, if your ADHD were a pie, one evidence-based therapy would eat about one third of it. Use another therapy and 30 percent more would be gone, and so on.

Which is best: medication or the non-medication therapies? The answer is not the scientifically accurate one, but the one that spilled out intuitively that day: 100-100. The best responses come with both therapies done at full-court-press levels. *—Tamara Rosier, Ph.D.*

On a hot summer day in my new office, my client and I were shivering cold. “The air conditioning is hyperactive, maybe?” I jokingly wondered as we pulled on sweaters. I turned the thermostat up to 76 degrees, then 80, but the cold air wouldn’t stop.

“Our HVAC system seems overactive,” I explained later to my husband. “Could it be too big for the office space?”

“It’s probably the thermostat, not the air-conditioner,” he said. His insight didn’t warm my office, but it made sense. It wasn’t a cooling-system problem, but a control-system problem. Punching temperature control buttons wasn’t helpful if the instructions weren’t getting to the air-conditioner.

A few days later, I met an office neighbor. When I told him about my problem, he proposed another theory: “Your thermostat doesn’t work. My thermostat controls your air conditioner. We aren’t really sure if it controls my offices. No matter how much I lower it, we’re always too hot.” A little more investigation revealed that his thermostat didn’t control my office, and that no one — not even the building’s owners — understood the wiring.

Understanding how ADHD brains are wired is critical for understanding how to explain and treat the disorder. For decades, we weren’t sure how ADHD brains worked, and this led to many misunderstandings about the syndrome. Many doctors, therapists, social workers, and coaches tried to teach ADHD children to slow down using the self-control methods that neurotypical children use. They thought they were programming the right thermostat.

“Take a deep breath and press the following buttons on your activity thermostat” makes sense if the wiring is standard, but not if the wires are connected differently, as they are in children and adults with ADHD. The most current research on brain imaging is starting to let us trace the wiring, so we can untangle the misconceptions that experts, as well as those with ADHD, have about the disorder and the brain. Our new understanding of the brain promises to change the way we treat ADHD.

The Brain Up Close

Researchers use structural imaging, which provides two- or three-dimensional pictures, to uncover the anatomy of the brain. Computed tomography (CT) scans and magnetic resonance imaging (MRI) are examples of structural imaging techniques. The images are used to measure the size and volume of the whole brain or specific areas within the brain.

To study brain functions, researchers use scans that show physiologic activity inside the brain. You've probably seen these studies covered in the press. The coverage usually includes statements like "X is the part of the brain that 'lights up' when people do Y." Older functional scans — electroencephalography (EEG) and single-photon emission computed tomography (SPECT) — measure patterns of nerve activity or blood flow, respectively. Newer methods, such as positron emission tomography (PET), use radioactive tracers that can be seen in the brain.

Much of what we know about dopamine function in the brain results from the radioactive tracer raclopride, which is injected into the body and attaches to empty dopamine receptors. Raclopride binding is higher in the brains of children or adults with ADHD, so we "see" that their dopamine activity levels are low. Raclopride binding drops to normal levels an hour after stimulant medications are taken. This is why neuroscientists now say that stimulants normalize dopamine function in the brains of people with ADHD.

Functional imaging gives information about activity in specific areas of subjects' brains before and during task performance. Functional magnetic resonance imaging (fMRI) shows oxygen uptake in areas of high nerve activity, and magnetoencephalography (MEG) shows us nerve activity in detail. A promising variant of fMRI, called fMRI-DTI (for diffusion tensor imaging), measures the connection between different regions of the brain. Crosstalk — the ability of different regions of the brain to communicate with each other — is vital to brain function, and it is significantly reduced in ADHD brains.

Many different techniques are used in brain imaging — though not all provide valid or generalizable information — and they give researchers useful glimpses into brain wiring and structure. In order to understand ADHD better and to treat it more effectively, we need to know the wiring of the brain and how it operates.

The ADHD Brain: Structurally Different

Neuroimaging studies have revealed the structural differences in the ADHD brain. Several studies have pointed to a smaller prefrontal cortex and basal ganglia, and decreased volume of the posterior inferior vermis of the cerebellum — all of which play important roles in focus and attention.

What this means. ADHD is not a difference in behavioral preference. Instead, ADHD appears to be partially attributed to a difference in how the brain is structured. What may look like behavioral choices — laziness, sloppiness, and forgetfulness — are likely due to differences in brain structure.

Researchers at Cambridge, England, and Oulu, Finland, followed 49 adolescents diagnosed with ADHD at age 16 and examined their brain structure and memory function in young adulthood (between 20 to 24 years old), compared to a control group of 34 young adults. The results showed that the group diagnosed in adolescence had reduced brain volume as adults, leading to poorer memory function, even if they no longer met the diagnostic checklist criteria for ADHD. Researchers saw reduced gray matter in a region deep within the brain known as the caudate nucleus, the brain region that integrates information across different parts of the brain and supports cognitive functions, including memory.

Because the structural differences persist into adulthood for most children with ADHD, the chance that a child will outgrow ADHD is not as great as we once thought. Sixty to 75 percent of adults who had ADHD in childhood continue to meet diagnostic criteria in adulthood. Most of those who "outgrow" ADHD continue to manifest many of its symptoms. Adults may score just under the cutoff on diagnostic checklists, but they are likely to continue to have abnormal brain structure, as well as functional impairments in relationships and the workplace.

The Changing Brain

Researchers once thought that each human function was assigned to a specific part of the brain, and that a part damaged by trauma or disease permanently lost its function. Now, research has shown that the human brain changes in response to stimulation; brains have neuroplasticity. The good news is that your brain retains this ability to change from birth to old age. ADHD brains that have deficits in one area will attempt to rewire themselves to accomplish a task.

There are activities that can increase the brain's effectiveness. Meditation, for example, changes the brain in important ways. Researchers worked with people who'd never meditated before (ADHD was not accounted for as a variable), and put one group through an eight-week mindfulness-based stress-reduction program. The primary difference was in the posterior cingulate, which is involved in mind wandering and self-awareness. Another notable change was in the left hippocampus, which assists in learning, cognition, memory, and emotional regulation. Subsequent studies applied this research using ADHD participants, and similar changes were noticed.

The ADHD Brain: A Network of Its Own

Researchers at Harvard University studied ADHD and non-ADHD subjects as they responded to a challenging cognitive task. While both groups had difficulty with the task, the ADHD group failed to activate their anterior cingulate cortex, which plays two significant roles in attentional processing: adjusting the focus of a person's attention (where and when) as well as balancing the focus of attention (how much attention for how long). ADHD participants engaged a different, less specialized part of their brain when tackling the task.

What this means. This research highlights what individuals with attention deficit already know. It is difficult to know what to do and when to do it. This is because of an apparent lack of ability to engage the most effective part of their brain, the anterior cingulate cortex.

The default mode network (DMN) represents the regions of the brain that are active when no specific task is being performed — while daydreaming, say, an activity that is undervalued by researchers and society. In the past, this was called the "resting state." Once functional scans showed how active the brain is at rest, the name was changed.

The DMN takes care of task-irrelevant mental processes, mind-wandering, contemplation, and reflection. It comprises the precuneus/posterior cingulate cortex, the medial prefrontal cortex, and the lateral and inferior parietal cortex. The DMN is more active when individuals are at wakeful rest, engaged in internal tasks, such as daydreaming, recovering memories, and assessing others' perspectives. Conversely, when individuals work on active, willful, goal-directed tasks, the DMN deactivates, and attentional pathways engage. The DMN and cognitive control networks work in opposing directions to accommodate attentional demands.

In ADHD, the daydreaming brain doesn't quiet down when the attention circuits turn on. Several studies have focused on the connectivity of the DMN in individuals with ADHD. Weak connections between control centers and the DMN cause an inability to modulate DMN activity. Many studies of children, adolescents, and adults with ADHD, taking and not taking medication, have found that the balance between the cognitive control network and the DMN is either reduced, or absent, in those with ADHD.

The lack of separation between the cognitive control network and the DMN in the ADHD brain suggests why there are attentional lapses. People with ADHD can instruct their focus control system to pay attention to the task at hand — say a pile of bills that need to be paid — but the circuits that connect to the DMN fail to send the instructions to quiet down. When the DMN notices a new magazine lying next to the pile of bills, emotional interest centers light up and overwhelm the weak voice of the cognitive centers.

We have come a long way from our earliest concepts of ADHD as hyperactivity to a dysfunction in the control pathways, but much remains to be studied. Finding which therapies strengthen control centers, which ones improve communication between control centers and action centers, and which ones bypass typical pathways will help adults with the disorder become more productive and confident.