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The Cognition Crisis

Anxiety. Depression. ADHD. Dementia. The human brain is in trouble. Technology is a cause — and a solution.




Adam Gazzaley MD, PhD [Follow](#)

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Our lives on this planet have improved in so many amazing ways over the last century. On average, we are now healthier, more affluent and literate, less violent and longer living.

Despite these unprecedented positive changes, clear signs exist that we are in the midst of an emerging crisis — one that has not yet been recognized in its full breadth, even though it lurks just beneath the surface of our casual conversations and swims in the undercurrents of our news feeds. This is not the well-known crisis that we've induced upon the earth's climate, but one that is just as threatening to our future. This is a crisis of our minds. A cognition crisis.

A cognition crisis is not defined by a lack of information, knowledge or skills. We have done a fine job in accumulating those and passing them along across millennia. Rather, this a crisis at the core of what makes us human: the dynamic interplay between our brain and our environment — the ever-present cycle between how we perceive our surroundings, integrate this information, and act upon it.

This ancient perception-action cycle ensured our earliest survival by allowing our primordial predecessors to seek nutrients and avoid toxins. It is from these humble beginnings that the human brain evolved to pursue more diverse resources and elude more inventive threats. It is from here that human cognition emerged to support our success in an increasingly complex and competitive environment: attention, memory, perception, creativity, imagination, reasoning, decision making, emotion and aggression regulation, empathy, compassion, and wisdom. And it is here that our crisis exists.

Today, hundreds of millions of people around the world seek medical assistance for serious impairments in their cognition: major depressive disorder, anxiety, schizophrenia, autism, post-traumatic stress disorder, dyslexia, obsessive-compulsive disorder, bipolar disorder, attention deficit hyperactivity disorder (ADHD), addiction, dementia, and more. In the United States alone, depression affects 16.2 million adults, anxiety 18.7 million, and dementia 5.7 million — a number that is expected to nearly triple in the coming decades.

American teens have experienced a 33% increase in depressive symptoms, with 31% more having died by suicide between 2010 and 2015.

The immense personal, societal and economic impact of cognitive dysfunction warrants heightened consideration because the crisis is growing, not receding. Despite substantial investment in research and treatments by governments, foundations, and companies around the world, the prevalence and impact of these conditions are escalating. Between 2005 and 2015, the number of people worldwide with depression and anxiety increased by 18.4% and 14.9% respectively, while individuals with dementia exhibited a 93% increase over those same years.

To some degree, these trends reflect the overall growth and aging of the world's population. This will only continue to increase in the future: the global population of seniors is predicted to swell to 1.5 billion by 2050. Although there are clear benefits to living longer, an unfortunate negative consequence is the burden it places on many aspects of cognition.

There are signs something else is going on, too. Over the last several decades, worrying tears have appeared in the cognitive fabric of our youth, notably in terms of emotional regulation and attentional deployment. American teens have experienced a 33% increase in depressive symptoms, with 31% more having died by suicide in 2015 than in 2010. ADHD diagnoses have also increased dramatically. While a growing awareness of these conditions — and with it, more frequent diagnoses — are likely factors, it does not seem this is the whole story; the magnitude of this escalation points to a deeper problem.

This has been better studied in the U.S. than abroad, but it is clear that this crisis is truly global, with the number of people suffering debilitating impairments in cognition exceeding half a billion worldwide, coupled with a financial toll in the trillions of dollars in lost productivity, healthcare costs and more.

[O]ur brains simply have not kept pace with the dramatic and rapid changes in our environment — specifically the introduction and ubiquity of information technology.

Even if an individual's cognition problems do not result in a medical diagnosis, subclinical deficits in attention, emotional regulation and memory have been found to confer a real risk. Creative thinking and empathic concern also appear to be declining in children and teens. Even the so-called Flynn Effect, which refers to a world-wide increase in intelligence over the last century, now shows signs of stagnation — and sometimes reversal — in developed countries.

While the sources fracturing our cognition are many, we are faced with the realization that our brains simply have not kept pace with the rapid changes in our environment — specifically the introduction and ubiquity of information technology. At our core, we humans are inherently information-seeking creatures. As a result, a profound shift in the flow of information will inevitably have major effects; and as we have come to see, many of these are negative.

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One Mind

While the many aspects of cognition — such as memory, attention, perception and emotional regulation — appear distinct on the surface, there are common threads that suggest their dysfunction are manifestations of a larger, more fundamental crisis. For instance, the prefrontal cortex, the most evolved region of the human brain, has been shown to support the full breadth of our cognition, and its dysfunction has been associated with symptoms of virtually every neuropsychiatric condition, from depression to ADHD. Simply put: what affects the prefrontal cortex can affect cognition more broadly.

It is a disservice to construct silos around each aspect of cognition and its accompanying dysfunction. We must see the forest for the trees.

Neuroscientists and leadership in the medical world now appreciate that much more unites seemingly disparate aspects of cognition than divide them. For example, attention deficits are now recognized to be a prominent feature of major depressive disorder, and are included in the most recent diagnostic criteria — the bible used by mental health experts — as a “diminished ability to concentrate.” The reality is that each of us has one mind, and embracing this will foster our ability to nurture it.

There is also, as I’ve said, a common, underlying aggravator that has exerted an impact across all domains of cognition: the dramatic plunge we’ve taken into the information age on the back of the digital revolution. Every way we interact with our environment, as well as with each other and ourselves, has been radically transformed by technology.

The old environment, where our cognition evolved, is long gone. The new environment, where multidimensional information flows like water (from a firehose!), challenges our brain and behavior at a fundamental level.

This has been shown in the laboratory, where scientists have documented the influence of information overload on attention, perception, memory, decision making, and emotional regulation. And it has also been shown in the real world, where we see strong associations between the use of technology and rising rates of depression, anxiety, suicide, and attention deficits, especially in children.

There is a common, underlying aggravator that has exerted an impact across all domains of cognition: the information age.

Although the exact mechanism is still under exploration, a complex story is emerging. We are seeing accelerating reward cycles associated with intolerance to delayed gratification and sustained attention; excessive information exposure connected with stress, depression, and anxiety (e.g., fear of missing out and being non-productive); and, of course, multitasking has been linked to safety issues (such as texting while driving) and a lack of focus (which impacts our relationships, our studies, and our work).

What's more, our constant engagement with technology interferes with the pursuit of other behaviors critical for maintaining a healthy mind, such as nature exposure, physical movement, face-to-face contact, and restorative sleep. Its negative influence on empathy, compassion, cooperation, and social bonding are just beginning to be understood.

The relatively young wellness movement, with ambitious goals of fostering and maintaining cognition throughout our lives, seems to understand this. Unfortunately, it's largely been marginalized as "alternative" and not given the benefit of mainstream concern.

There's cause for alarm, but it's not all doom and gloom. The information age has offered us a tremendous opportunity to expand our consciousness and connect with one another like never before. It has helped reduce inequities arising from lack of resources by providing training and education to people who may not have access to high-quality teachers or institutions.

Fortunately, the negative consequences of information technology are increasingly being recognized by both entrepreneurs who've created them and consumers who ravenously devour them. Fresh ideas have emerged regarding how we might modify our behavior to foster healthier habits of engagement with software and devices so that we are the ones in control and not the other way around.

We should think about the consumption of information in a similar manner to how we view the consumption of food. Still, behavioral change alone will not be enough, because the stakes will only get higher in the future, where we may very well find ourselves immersed in virtual and augmented realities, with our interactions being guided by artificial intelligence.

We are not putting the tech genie back in the bottle.

We are coming to realize that we need to get out in front of this by designing new technologies in a manner that is informed by a deeper understanding of how our brain functions — its limitations and vulnerabilities.

We are not putting the tech genie back in the bottle. Next-generation information technology, even when thoughtfully designed and well-

intentioned, will likely continue to stress our brains. That's why we need to recognize the full extent of its influence — and explore creative approaches to addressing it.

So, what do we do? We must also enhance cognition itself.

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The Cognition Challenge

We need better brains to manage the deluge of information we consume on the internet, on social media, on our smartphones today — as well as the new technologies we'll surely encounter tomorrow. We need to elevate the maturity of our collective consciousness in order to thrive in this new environment.

This calls for something big: coordinated effort by major actors, from the White House and the National Institutes of Health to the United Nations and the power brokers at Davos. Indeed, addressing the cognition crisis should be positioned as a grand challenge, on par with other pressing global priorities, such as eradicating infectious diseases and disseminating clean water.

Success in solving such global challenges depends upon us having the mental capacity to actually solve them: high-level attention, reasoning, creativity, decision making, compassion, and wisdom are required. If we can't focus our attention and make creative, wise, and more future-oriented decisions, we will never effectively deal with complex, time-delayed crises like the one affecting our climate, no matter how much information we acquire.

The idea of a global enterprise directed at enhancing ourselves should not seem foreign. We humans have long been obsessed with biological

self-optimization. When it comes to our physical bodies, abilities such as strength, endurance, power, speed, balance, flexibility and coordination have all been targeted for improvement with specialized technologies and programs delivered by trained practitioners.



We have developed these approaches to yield physical enhancements with benefits aimed toward entertainment, fitness, athletics, sports, and rehabilitation. But we are tragically lacking when it comes to optimizing our cognition. The price for this neglect is tough to overstate.

To have a consequential and enduring impact, a grand challenge of cognitive enhancement needs to be positioned as a broad pursuit, directed at enhancing cognition in those of us who are healthy, as well as those suffering from incapacitating deficits in cognition. At the boundaries, these groups blur. Fortunately, we have two major institutions — our education and medical systems — that parse the population in this manner and seem well positioned to tackle a challenge like this one.

To that end: developing and enhancing cognition for healthy brains

should be a core mission of our educational institutions, and remediating cognitive deficits should be a major goal of our medical system. Right now, neither of these incumbents are effectively doing so. From teachers to therapists to psychiatrists to neurologists, our cognition practitioners are simply not equipped with the tools or training needed to face the challenges that our brains now endure.

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Status Quo

To understand why we're not currently equipped to address the crisis, it's helpful to look at five factors in our education and medical systems that perpetuate it: Inadequate assessments of people's cognitive abilities and challenges; poorly targeted treatments for cognitive problems such as attention and memory deficits or depression and anxiety; a lack of personalized treatments; medical and educational practices that work in silos; and open-loop systems (defined as the absence of real-time, quantitative feedback to guide dynamic adjustments of an intervention).

Consider what this looks like in action:

Sarah is a 65-year-old woman who presents to her doctor with concerns about her attention. She feels overly distracted and is alarmed by increasingly frequent "senior moments." Following an outdated, inadequate paper-and-pencil test, the first she has ever taken, which is unaccompanied by functional brain imaging (inadequate assessments), she is placed on a drug used to treat dementia — an acetylcholinesterase inhibitor (poor targeting) — whose starting dose was based on population data from a large clinical trial (non-personalized), and prescribed to her in isolation, without adjunct physical exercise despite the vast amount of research that support this recommendation (siloed practices). After

several months, with only subjective monitoring of her effects and side effects, she returns to see her doctor for a visit. Inadequate testing, once again in a stressful clinic environment, leads to a dosage adjustment without an informed basis of how this will impact her, setting off another round of extended trial-and-error (open-loop system).

Sarah might be fortunate enough to have been seen by a top-notch physician, who recognizes the flaws in the status quo and improves upon it by offering extensive neuropsychological testing, and a treatment that is a bit more personalized — perhaps starting with a half dose, because of a suspected intolerance. That physician would also take a multimodal approach, encouraging physical exercise, and not let her go so long without checking in on her side effects and progress in order to make dosage adjustments. Even this approach, which is as good as it currently gets, still falls tragically short of the transformative care that we should be delivering.

This is the disheartening reality that all patients face when suffering from neurological and psychiatric conditions. Advances in functional brain imaging, which have successfully been used to understand brain and cognition in the laboratory, have not jumped the gap to inform real-world practices and an understanding of each person's brain. When a clinical provider does diagnose a patient with impairments in cognition, pharmaceuticals are prescribed to treat their symptoms. Unfortunately, all of these medications in a physician's toolkit are blunt instruments that broadly influence neurotransmitter systems and do not selectively target underlying brain networks.

For some conditions, these medications can be life-savers. Yet without attaining specificity to brain networks or directly altering the pathology of a disease, our treatments remain highly imprecise and thus loaded with side effects. There is nothing conceptually wrong with the idea of using a small molecule to improve cognition, but pharmaceutical

treatments have not shown major advances in this domain for many decades.

The use of imprecise, inaccessible, and outdated assessments of cognition dominates the mental health world. This is coupled with poorly targeted, siloed, non-personalized, open-loop treatments that extend across the full breadth of disorders: major depression, post-traumatic stress disorder, anxiety disorder, attention deficit hyperactivity disorder, autism, dyslexia, traumatic brain injury, Alzheimer's disease, Parkinson's disease — all of them.

The scenario becomes even more complicated when cognitive challenges arise in children because of the same limitations in our approach to education:

Peter is an 11-year-old boy whose parents are concerned he might be having attention issues. He is doing fairly well in school, maintaining a B average, but is described as being on the wild side. Although his teachers share some of these concerns, he has never received a cognitive evaluation (inadequate assessments) or any type of intervention directed at improving his attention. What is unknown to everyone is that Peter's sustained attention abilities are significantly below average for his age. A detailed cognitive assessment at this time would have made this clear, and also revealed that he was above average in other cognitive areas, which allowed him to effectively compensate for his poor attention. This knowledge may have led to him receiving a targeted, personalized, closed-loop intervention to enhance his sustained attention abilities — but this is not what happens.

Children take exams that evaluate their ability to regurgitate recently consumed information, but how well they sustain their attention and regulate their emotions is rarely taken into account unless a learning disability is suspected. Back to Peter. Suppose that his parents or

teachers become convinced that Peter's attention problems are actually symptoms of a "clinical" condition, his transition from the education system to the medical system would be just as problematic.

When Peter turns 12, he starts junior high, which is a disorienting whirlwind and further challenges his fragile sustained attention abilities. His grades suffer and his behavior degrades. As his social functioning becomes impaired he spends more time with deviant peers, leading to his first engagement with substance use. His teachers are not pleased and he is sent to the school nurse for an evaluation. This leads to a visit to a psychiatrist and his first formal assessment. However, this assessment does not include any measure of actual cognition (inadequate assessments). The evaluation earns him the diagnosis of ADHD and a daily helping of the standard dose of Adderall (non-personalized).

Just like that, he went from being a student to being a patient. After the treatment starts he is more docile and gets in less trouble in class, but his grades do not improve (poor targeting). The lack of a complementary behavioral intervention makes it impossible for him to develop the complex skills required for him to master more challenging academic demands (siloe practices). He and his parents are also increasingly troubled that his formally explorative personality now seems to be suppressed, but the infrequent and non-informed adjustments of drug dosage never correct this issue (open-loop system).

Inadequate assessments, poor targeting, lack of personalization, siloe practices, and open-loop systems are the major issues that impede our educational and medical institutions from delivering effective interventions that enhance, or at least maintain, our cognition at a high-level. These are not the fine details of a well-oiled machine that are in need of tweaking. These are critical and fundamental flaws at the core of humanity's incumbent systems of cognition enhancement.

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The Future

This is a perfect opportunity for the same technologies that are a source of the cognition crisis to play a positive role in enhancing what makes us human, rather than diminishing us.

Mobile technologies are now being developed that wield a wide spectrum of sophisticated sensors. Touch screens, accelerometers, GPS, voice recognizers, heart rate trackers, facial expression detectors, eye motion capturers, and brain activity recorders (e.g., EEG) can be utilized to collect and interpret both passive and active data about us. This technology is ideally positioned to serve as the foundation for the next generation of cognition assessments, allowing us to better and more deeply understand ourselves in the real-world and in real-time.

Tech-based assessments could be optimized to yield a much more nuanced perspective of our abilities, such as how facets of cognition are stable traits, while others are fluid states that dynamically shift with our environment and physiology (e.g., intoxication, fatigue and stress). They could allow us to explore the eddies and tides in cognition on our journey from childhood to our senior years, and in response to life's unpredictable joys and traumas.

Of course, this approach needs to advance with careful attention to protect sensitive data, as well as ethical considerations to understand and preempt its abuse. Obtaining this knowledge about ourselves will be also coupled with an inevitable burden to overcome deeply rooted biases that exist around cognition. For some, there will be an unsettling concern about tracking attention, memory, and decision making, which does not apply to testing cholesterol, glucose, and blood pressure. This issue parallels the major stigma that exists for mental health disorders

as being reflective of the quality of a person rather than a medical condition.

There seems to be a natural inclination to think of cognition as a reflection of “who we are” more than other aspects of our biological functioning. We might refer to someone as *being* inattentive, and as *having* high blood pressure. The former is something that defines them as a person, often accompanied by moral judgment, while the latter as something that is inflicted upon them and viewed as a simple biological “fact.” These biases need to go.

[T]he same technologies that are a source of the cognition crisis can play a positive role in enhancing what makes us human.

Once we obtain a more precise understanding of our cognition, the next goal is to enhance it. Before diving into the opportunity for technology to help with this, it is important to recognize that there is plenty we can do by refining our daily activities. Extensive research has revealed benefits on cognition from more informed decisions about physical exercise, cognitive challenge, social interactions, sleep, nutrition, music, dance, and time in nature.

Some of the most ancient and formalized practices that we humans engage in are at their very core cognition enhancing exercises: mindfulness practices and contemplative traditions. Promising research supports the beneficial effects of meditation on mood, attention, compassion, and stress management.



For too long wellness and medicine have been considered distinct disciplines, and healthcare has essentially been sickcare. A stronger scientific foundation supporting the benefits of these approaches will allow us to finally break down barriers that have thwarted advances in preventative treatments. Empirical evidence supporting these practices needs to become indistinguishable from those generated for regulated mainstream solutions.

Our challenge now is to figure out how we can use technology to create powerful experiences that maximally harness our brain's plasticity to enhance our cognition, refine our behavior and ultimately elevate our minds. Clearly, not all experiences are created equal. The most effective type of experience that can accomplish such a high-level goal is the *closed-loop experience*.

Closed-loop systems are currently used in many physical applications; even our home appliances, such as thermostats and dryers, use closed-loop designs by sensing temperature and moisture to determine how much heat to supply. But its use is almost non-existent for biological applications. And as described, both our education and medical systems utilize open-loop systems.

Our challenge is to figure out how to use technology to create powerful experiences that elevate our minds.

A technology-based, closed-loop approach can be used to generate an experience that activates brain networks in a selective manner (that's how the brain works) and then applies constant pressure to the network via interactive challenges that drive the brain's plasticity to optimize its function over time.

Imagine playing a video game where data about you in the moment is being collected with sensor technology — performance metrics, emotional responses, body movements, brain activity — and this is used in real-time to guide the environment you are experiencing, personalizing both challenges and rewards to improve your cognition. It would be like sparring with the ultimate personal cognition trainer.

Many laboratories and companies around the world are actively pursuing this vision right now. This includes my own efforts in technology incubation and scientific research into how closed-loop video games may serve as cognitive enhancement tools that advance a new approach: *digital medicine and digital education*. This re-imagination of non-invasive, affordable, safe and accessible technology — smartphones, tablets, wearable physiological devices, motion capture and interactive media — as instruments to better understand and improve our minds has great potential to address the cognition crisis.

Take all of this one step further into the future and picture the role that innovations in artificial intelligence (A.I.) and virtual reality (VR) technologies can offer here. Now imagine yourself deeply immersed in

a multi-sensory virtual environment where your full-body interactivity is coordinated by an A.I. that knows you better and deeper in that moment than any human being would be capable of, including yourself. It would create for you a perfectly targeted, closed-loop experience aimed at enhancing and maintaining all aspects of your cognition at a high-level throughout your life — picking up on subtle shifts in perception, mood, aggression, attention, and memory to strengthen your brain's function by driving its natural plasticity. This would not be designed to control you, but rather to give you control over your own mind and prevent (or at least delay) the slippery slide into major depression, anxiety, ADHD, and dementia.

What better use is there for A.I. than in enhancing H.I. — human intelligence? If we are creative and forward-thinking, we can achieve what may be technology's ultimate promise, the establishment of an environment that fosters the next phase in the evolution of the human mind.

What better use is there for A.I. than in enhancing H.I. — human intelligence?

Advances in medicine over the last hundred years have resulted in an elevation of the overall health of humanity to a level that far exceeds what has ever been attained in the past. Technology has been a big part of this success. But for our species to continue to thrive and flourish in this increasingly complex world, we must engage in the difficult task of turning our lens inward and looking carefully and honestly for cracks in the mirror.

A crisis is a time of difficulty when important decisions must be made to avert future disaster. When it comes to the functioning of our brains

and minds, the time has arrived. The status of our cognition on a global scale is in trouble — and getting worse, especially for our children. For too long we have maintained the illusion that we are separate from our environment. Now is the time to take stock of what we truly value in being human, embrace it and mend our broken minds.

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