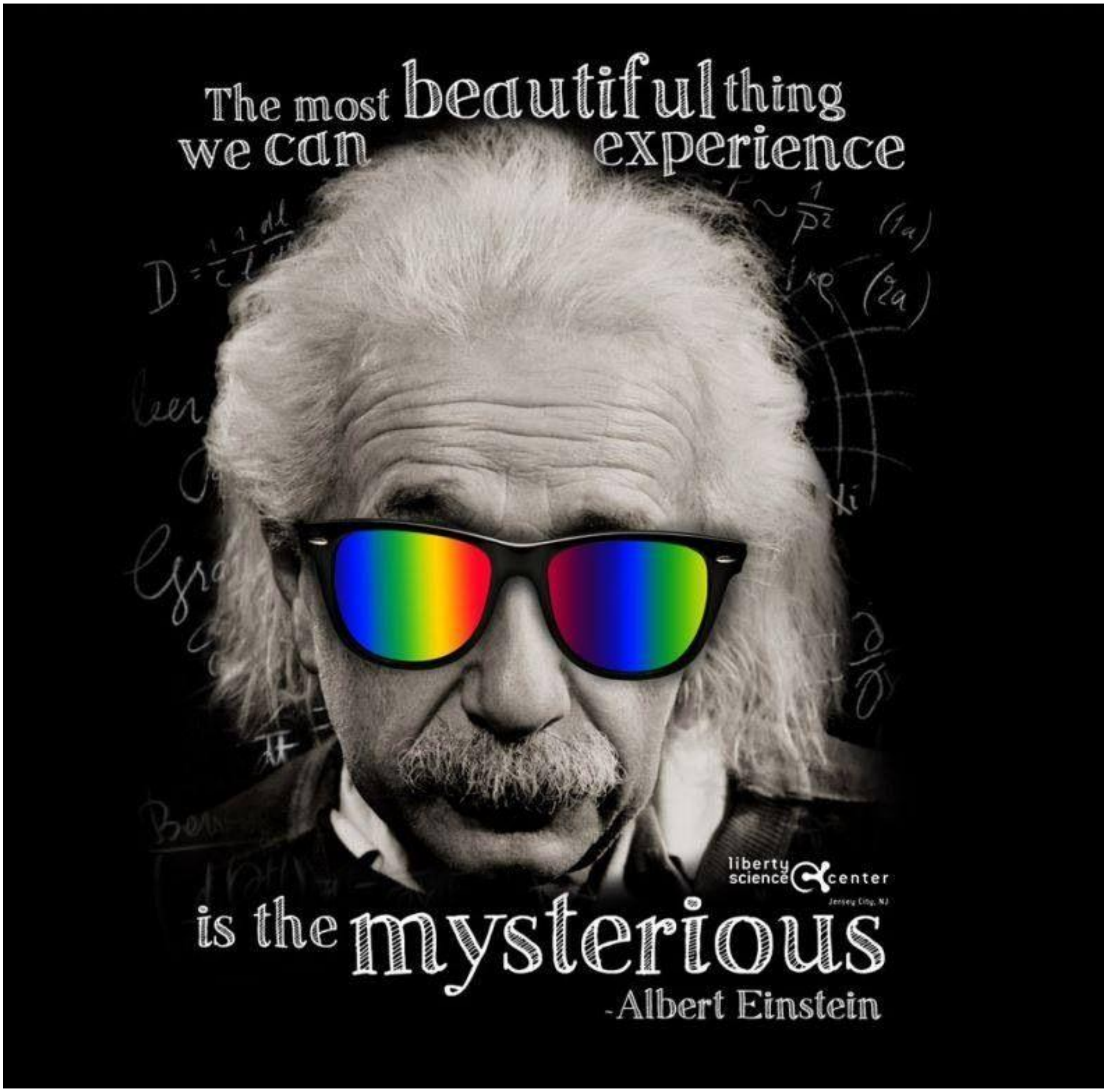
DESIGN THEORY



How to break through a creativity block

It's a telling tale: Sometimes, as a leader, the best way to spark creativity is to go straight to the front line—to spend time with employees across the company, and if your business is international, across the globe. Especially if you're experiencing a creative block, a tour of your office can ignite ideas and solutions.

We all face creativity blocks. But here are some ways you can seek out inspiration from your colleagues get out of a rut:

Volunteer to be the notetaker

In the past, leaders could get away with problem-solving and decision-making by consulting a small circle of advisers. Today, the nature of work has changed, along with the nature of problems. Technology is advancing more rapidly than ever, customers have higher expectations, and, of course, global issues like climate change are more pressing than ever. Increasingly complex problems require increasingly innovative solutions.

As research published by Harvard Business School suggests, today's leaders have to gather input and buy-in from a larger and more diverse range of experts. This new landscape makes social skills like listening more critical than ever.

For leaders, the expectation is often that we communicate our ideas, our expectations, and our vision. Listening, on the other hand, is sorely underrated—especially when you're searching for creative ideas. As you connect with your coworkers looking for inspiration, one way to ensure you're listening more than speaking is by volunteering to be the notetaker. When you attend meetings, record each participant's input. Even if you're using an AI-powered note taking app, you can spearhead the process of capturing and organizing everything discussed. Resist the urge to weigh in, even if employees look to you to resolve open questions. Remember, brainstorming is about the process.

Schedule one-on-one meetings

While group meetings are a great way to get the ball rolling, scheduling one-on-one meetings can help flesh out your ideas—especially if an employee is on the introverted side of the spectrum.

Writing for *Fast Company*, Evans Baiya explains that engaging quieter team members and finding the ideal way to work with them can lead to "a gold mine of well-thought-out and creative ideas that are even deeper and more developed than what you get in a quick brainstorm session."

Regardless of an employee's personality type, Baiya's tips can help make your one-on-one meetings more productive. Provide employees with detailed information about the issue in advance, allowing them time to reflect before the meeting. This gives everyone, even extroverts who may prefer thinking on their feet, a chance to enter the discussion on equal footing, ensuring more thoughtful and creative input.

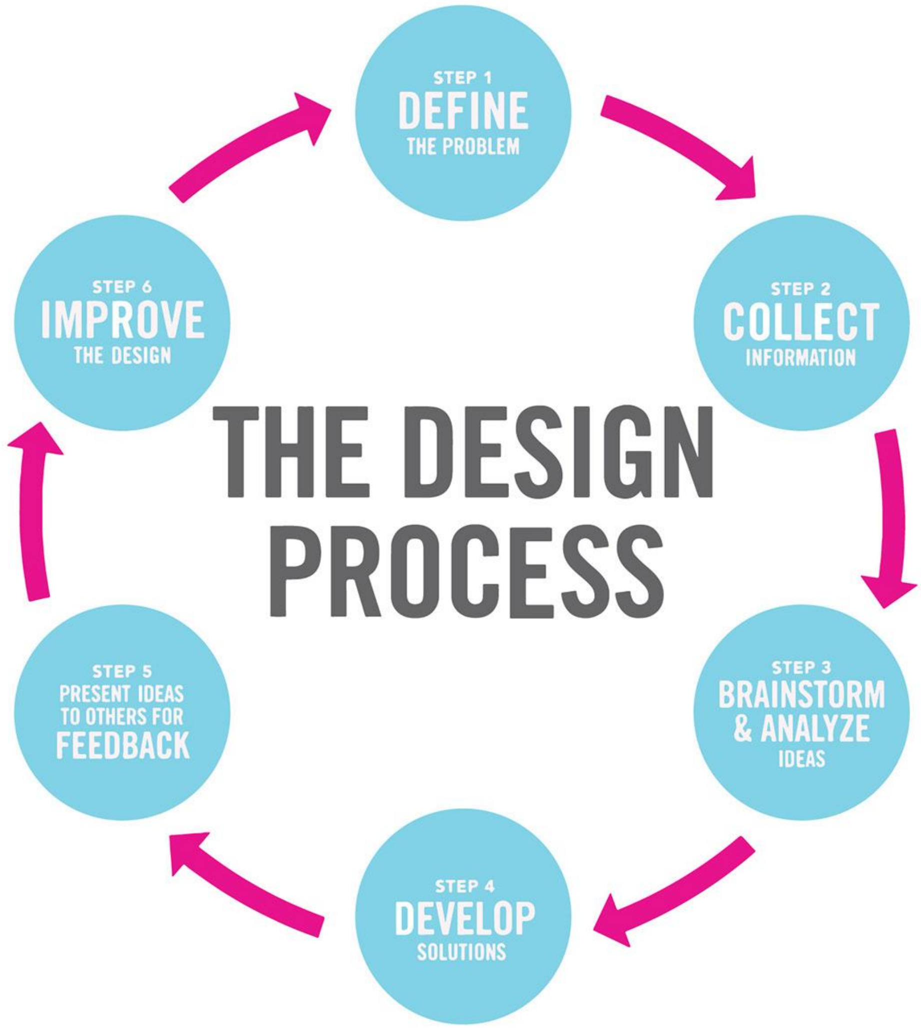
Pull together a recap document

The final step is to recap all that you have learned and how your colleagues have inspired you. Like leaving a networking event with empty pockets versus a stack of business cards, this final effort makes the difference between mere socializing and meaningful productivity.

When I visit Jotform's various offices, I often take the last half-hour of the day to pull together a recap. Using my meeting notes, I outline key contributions, takeaways, and open questions. I list new objectives. And I summarize any points or issues I'd like to explore.

Compiling my notes helps me to reflect on and expand on ideas. Sometimes, it helps me to recognize that an idea isn't worth pursuing. Other times, it helps me ensure that good ideas don't slip through the cracks.

Preparing a recap document also helps me improve my time management. If, for example, I realize that the day didn't get my creative wheels turning, I might rethink how I'm spending my time. For example, I might choose to sit in on fewer group meetings in favor of more one-on-ones. As much as I appreciate the added facetime, the goal is to spark new ideas. Hopefully, with these strategies, you'll be equipped to break through your next creative rut and find your next great idea, too.



Want Better Mental Focus? Neuroscience Just Explained How to Train Your Brain to Achieve 'Flow State'

You might call it 'flow state' or 'being in the zone.' Would you be interested to learn how to make it happen?

This is a story about creativity, productivity, and neuroscience.

In 1990, a psychologist named Mihaly Csikszentmihalyi published a book in which he described "flow," a state of mind in which people can focus their brains, shut out distractions, and become much more productive.

Maybe you think of this as being "in the zone." People have spent entire careers trying to explain, analyze, and ultimately teach others how to enter into this kind of flow state.

Now, researchers out of Drexel University in Philadelphia say they've succeeded in using neuroimaging technology to track flow state in people's brains in real time -- and maybe unlock some practical advice on how to make it happen.

Writing in the journal *Neuropsychologia*, the researchers said they set out to consider two theories of how flow state might work:

- Theory 1 suggests that flow state might simply be, "a state of highly focused concentration or hyperfocus that shuts out extraneous thoughts and other distractions to enable superior performance on a task."
- Theory 2, however, suggests something a bit more active: The idea that through years of intense practice, people's brains can develop "a specialized network or circuit to automatically produce a specific type of ideas... with little conscious effort."

If the second theory were correct, the researchers hypothesized, this might mean that the brains of people who develop a certain level of expertise in a creative discipline might be able to "rela[x] its supervision" and basically go on autopilot -- flow state, almost on demand -- exploring and creating without active control.

"Csikszentmihalyi... defined [flow] as 'a state in which people are so involved in an activity that nothing else seems to matter,' " said lead researcher John Kounios. "'[T]he experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it.'"

The Drexel experiment involved recruiting a group of 32 jazz guitarists, some of whom were highly experienced and others who were less so, and recording high-density electroencephalograms (EEGs) while they each improvised six jazz sessions, "with programmed drums, bass, and piano accompaniment."

Afterward, their performances were assessed both by (a) asking the guitarists to rate how intensely they felt they achieved a "flow state" while playing, and (b) asking four jazz experts to listen individually to each of the 192 total recorded improv sessions, and rate them for creativity and other qualities.

In the end, they made two very interesting findings:

- First, the more experienced musicians reached a flow state "more often and more intensely" than their less experienced colleagues -- thus suggesting support for "Theory 2," above.
- Second, they found that the EEGs mapping the brain activity of musicians who managed to achieve a high state of flow had two marked differences from other occasions: *increased* brain activity in the left hemisphere, in areas associated with "hearing and playing music," and *decreased* activity in the *superior frontal gyri*, which is associated with executive control.

What I really like about this effort is that Kounios was willing to make a few recommendations for creative people in any field who might want to increase the odds of attaining flow state.

In short, he said it involves building deep expertise in whatever creative discipline you care for, and then also practicing and also learning how to "withdraw conscious control" once you've reached that high level of expertise.

As I write in my free e-book, *Neuroscience: 13 Ways to Understand and Train Your Brain for Life*, there's nothing more fascinating than the human brain and the unexpected ways in which it works. Techniques like this to improve focus are at the top of the list.

Or to quote Kounios once more: "As jazz great Charlie Parker said, 'You've got to learn your instrument. Then, you practice, practice, practice. And then, when you finally get up there on the bandstand, forget all that and just wail.'"

BREAKTHROUGH STUDY SHEDS LIGHT ON THE RIDDLE OF HUMAN CREATIVITY

TIM MCMILLAN·AUGUST 12, 2024

Neuroscientists have pinpointed a specific brain region that plays a pivotal role in human creativity, according to the results of a groundbreaking new study.

Published in the journal *BRAIN*, the new study reveals that the brain's Default Mode Network (DMN) plays an instrumental role in driving one of humanity's most mysterious and defining characteristics—creativity.

"Our results suggest that DMN activity is flexibly modulated as a function of specific cognitive processes and supports its causal role in divergent thinking," researchers wrote. "These findings shed light on the neural constructs supporting different forms of cognition and provide causal evidence for the role of DMN in the generation of original connections among concepts."

Creativity has long been recognized as a hallmark of human intelligence, setting us apart from all other animals. It is the spark that has driven humanity to produce everything from masterpieces like Leonardo da Vinci's Mona Lisa and William Shakespeare's Hamlet to countless revolutionary technological innovations. However, the precise neural mechanisms underlying creativity have remained elusive despite its importance.

A recent study by researchers from the University of Utah Health and Baylor College of Medicine has provided compelling evidence that the brain's Default Mode Network (DMN) is central to generating creative ideas.

The DMN is a large-scale interconnected network primarily composed of the dorsal medial prefrontal cortex, posterior cingulate cortex, precuneus, and angular gyrus regions of the brain. It is most known for being active when the conscious mind is at rest, such as during daydreaming or mindfulness meditation.

Previous research has shown that the DMN becomes deactivated during goal-oriented tasks, such as those requiring visual attention or working memory. These findings have led cognitive scientists to conclude that the network is crucial for the brain's ability to generate thoughts independent of the immediate external environment, making it essential for imagination, creativity, and the ability to draw connections between seemingly unrelated ideas.

To better understand the mystery of how the brain generates creative ideas, researchers examined 13 study participants receiving treatment for epilepsy at Baylor St. Luke's Medical Center that had Stereoelectroencephalography (sEEG) electrodes surgically implanted in their brains for seizure mapping.

By using participants with intracranial electrodes, researchers could record brain activity with exceptional temporal and spatial precision as they engaged in tasks designed to stimulate creative thinking.

These tasks included generating novel uses for everyday objects, a well-known test of creativity often called the "alternate uses task." Participants were also asked to engage in a "mind-wandering task," which involved focusing on neutral visual stimuli and allowing their thoughts to roam freely. Finally, participants were given a third "sustained attention task" as a control measure.

By comparing brain activity during these tasks, the researchers discovered that the DMN and brain regions, typically associated with introspection and daydreaming, were highly active during creative functions.

In addition to mapping the brain regions involved in creativity, the researchers also examined the specific types of brain waves that were most active during creative tasks. Specifically, they focused on two types of brain waves: theta and gamma.

Previous research has linked theta waves to long-range communication between brain regions and states of relaxation and meditation. Meanwhile, Gamma waves are often associated with local neural activity and are believed to be involved in moments of insight or the formation of unified perception.

Researchers found that during the creative tasks, there was a notable increase in gamma wave activity in the DMN, suggesting that this brain region is not only active during creative thinking but may also orchestrate and integrate different types of information necessary for creative insights.

Meanwhile, theta wave activity was also heightened, particularly in the moments leading up to the generation of a creative idea, indicating that a relaxed, open mental state might be a precursor to creativity.

These results suggest that the interplay between theta and gamma oscillations in the DMN is crucial for generating creative ideas. This aligns with the notion that creativity involves a free flow of ideas, facilitated by a relaxed mental state, and the ability to synthesize these ideas into something new and useful, driven by more focused, integrative processes.

To confirm the DMN's role in creativity, researchers used electrical stimulation to temporarily disrupt activity in specific network regions. This approach allowed them to observe how reducing DMN activity affected participants' creative thinking.

The findings showed that participants' ability to generate creative ideas was significantly impaired when DMN activity was disrupted during "alternate uses tasks." However, intriguingly, disruptions to the neural network did not affect performance in mind-wandering tasks.

"Our results indicate that the thought processes occurring during daydreaming and mind wandering are more resilient to external perturbation of the system," researchers wrote. "It is possible that changes in the train of thoughts might be more difficult to detect given their "unconstrained" fluctuating nature, also in line with the subjective experience of a constant and coherent internal narrative."

The implications of this recent research are profound. Understanding the neural basis of creativity could lead to new ways of enhancing creativity in individuals, whether through educational techniques, cognitive training, or even brain stimulation technologies.

Moreover, this knowledge could inform the development of artificial intelligence systems that better mimic human creativity, potentially leading to more innovative and adaptable AI.

However, researchers caution that creativity is a complex, multifaceted phenomenon, and this latest research only focused on specific regions within the DMN. Previous studies have shown that creativity and divergent thinking can involve additional cognitive control networks.

"To better quantify the relationship between these various networks, future studies focused on measures of network synchrony, such as cross-frequency coupling and phase synchronization, will be necessary," researchers wrote.

In the broader context, this understanding reinforces the idea that creativity is a defining feature of the human experience, rooted in the unique architecture of our brains.

Moreover, these findings challenge previous notions that the DMN plays a passive role in supporting mind-wandering and self-referential thoughts. Instead, the neural network is actively engaged in generating creativity and the imaginative thought process.

Ultimately, in a world where innovation is increasingly critical, this new understanding of how creativity arises in the brain could prove invaluable, offering new avenues for fostering creativity in individuals and societies.

User Brain: Harnessing Cognitive Science for Intuitive Design

Neuromarketing

NeuroLaunch editorial team

September 30, 2024

Quick Navigation

The key to designing intuitive digital experiences lies in understanding the user's brain—a complex, cognitive puzzle that UX designers must solve to create interfaces that feel effortless and engaging. This concept, often referred to as the "user brain," has become increasingly crucial in the realm of modern digital experiences. As we navigate an ever-expanding digital landscape, the ability to craft interfaces that resonate with our cognitive processes has never been more important.

But what exactly is the user brain? It's not just a catchy phrase; it's a fundamental approach to design that draws upon the principles of cognitive science to create user experiences that feel natural and intuitive. By understanding how our brains process information, make decisions, and form memories, designers can craft digital environments that work in harmony with our mental processes rather than against them.

The importance of this approach cannot be overstated. In a world where attention is a precious commodity, and users have countless options at their fingertips, designing for the user brain can mean the difference between an app that becomes a daily habit and one that's quickly forgotten. It's about more than just making things look pretty; it's about creating experiences that feel like second nature.

To truly grasp the concept of user brain, we need to take a quick dive into the world of cognitive science. This interdisciplinary field combines insights from psychology, neuroscience, and computer science to understand how the mind works. For UX designers, it's a goldmine of knowledge that can inform every aspect of the design process.

Understanding the User's Mental Model

At the heart of designing for the user brain is the concept of cognitive load theory. This theory suggests that our working memory has a limited capacity, and when we overwhelm it with too much information or complexity, our ability to process and retain information suffers. It's like trying to juggle too many balls at once – eventually, something's got to give.

This is where the idea of schema comes into play. Our brains are constantly trying to make sense of the world around us by organizing information into mental frameworks or schemas. When we encounter a new interface, we automatically try to fit it into our existing schemas. If it aligns well, we find it intuitive. If it doesn't, we struggle.

Think about the first time you encountered a smartphone interface. It probably felt a bit overwhelming at first. But as you used it more, your brain created new schemas to understand and navigate this digital environment. Now, you probably don't even think about how to use your phone – it just feels nature.

Perception and attention play crucial roles in how we interact with digital interfaces. Our brains are constantly filtering the massive amount of sensory information we receive, focusing on what's deemed important and ignoring the rest. This is why Brain Hook: The Psychological Technique That Captures Attention is so crucial in design. By understanding how to capture and direct user attention, designers can create more engaging and effective interfaces.

Memory and recall are also key considerations. How easily can users remember where to find certain features? How intuitive is the navigation? These questions tap into our understanding of how the brain forms and retrieves memories. By aligning interface design with these cognitive processes, we can create experiences that feel more natural and require less mental effort to use.

Applying User Brain Principles in Design

Now that we've laid the groundwork, let's explore how these principles translate into practical design strategies. One of the most fundamental aspects is visual hierarchy and information architecture. Just as our brains organize information into schemas, good design organizes visual elements in a way that guides the user's attention and helps them make sense of the interface.

This is where Gestalt principles come into play. These principles, derived from psychology, describe how our brains tend to group and organize visual elements. For example, the principle of proximity states that we perceive elements that are close together as being related. By leveraging these principles, designers can create interfaces that feel intuitive and easy to navigate.

Color psychology is another powerful tool in the designer's arsenal. Colors can evoke emotions, guide attention, and even influence decision-making. By understanding the psychological impact of different colors, designers can create interfaces that not only look good but also feel good to use.

Microinteractions and feedback loops are the unsung heroes of user experience. These small, often overlooked details can make a huge difference in how intuitive an interface feels. A subtle animation when you like a post, the satisfying "whoosh" sound when you send an email – these microinteractions provide immediate feedback that aligns with our brain's expectation of cause and effect.

User Brain and Decision-Making

Understanding how users make decisions is crucial for creating interfaces that feel natural and effortless. This is where choice architecture comes into play. By carefully structuring the options presented to users, designers can guide decision-making without overwhelming the user's cognitive resources.

However, it's important to be aware of decision fatigue. Our brains have a limited capacity for making decisions, and each choice we make depletes this resource. This is why many successful apps and websites aim to reduce the number of decisions a user needs to make, especially for routine tasks.

Heuristics and cognitive biases also play a significant role in user behavior. These mental shortcuts help us make quick decisions, but they can also lead us astray. By understanding these biases, designers can create interfaces that work with our natural thought processes rather than against them.

This brings us to the topic of persuasive design techniques. While these can be powerful tools for guiding user behavior, they also raise important ethical considerations. As designers, we have a responsibility to use these techniques in ways that benefit the user, not just the business. It's a delicate balance that requires constant reflection and adjustment.

Measuring and Optimizing for User Brain

So how do we know if our designs are truly aligning with the user's cognitive processes? This is where measurement and optimization come in. Eye-tracking studies and attention heat maps can provide valuable insights into how users visually process an interface. These tools allow designers to see exactly where users are looking and for how long, helping to identify areas of confusion or interest.

A/B testing is another powerful tool for cognitive optimization. By comparing different versions of an interface, designers can see which one performs better in terms of user engagement and task completion. This data-driven approach allows for continuous improvement based on real user behavior.

User feedback and qualitative research methods are equally important. While quantitative data can tell us what users are doing, qualitative research helps us understand why they're doing it. This deeper understanding of user motivations and thought processes is crucial for designing truly intuitive interfaces.

In recent years, neuromarketing techniques have also made their way into UX research. These methods use neuroscience tools to measure brain activity and physiological responses as users interact with digital interfaces. While still a developing field, it offers exciting possibilities for gaining deeper insights into the user brain. As explored in Brain Sells: Unlocking the Power of Neuromarketing in Modern Advertising, these techniques are already revolutionizing how we approach user experience design.

Future Trends in User Brain Research

As technology continues to evolve, so too does our understanding of the user brain. Artificial intelligence and machine learning are opening up new possibilities for predicting user behavior and creating more personalized experiences. Imagine an interface that adapts in real-time to your cognitive state, presenting information in the most optimal way for your current mental capacity.

Virtual and augmented reality interfaces present exciting new challenges and opportunities for user brain design. These immersive technologies have the potential to create experiences that feel more natural and intuitive than ever before, but they also require a deep understanding of how our brains process three-dimensional space and movement.

Personalization and adaptive user experiences are likely to become increasingly sophisticated. As we gather more data about individual users' cognitive preferences and behaviors, we can create interfaces that feel tailor-made for each person. This level of personalization could dramatically reduce cognitive load and make digital experiences feel more effortless than ever.

Accessibility and inclusive design for diverse cognitive abilities is another crucial area of development. As our understanding of neurodiversity grows, so too does our ability to create interfaces that work well for people with different cognitive strengths and challenges. This isn't just about accommodating disabilities; it's about recognizing and designing for the full spectrum of human cognitive diversity.

The concept of Grug Brain: Exploring the Concept and Its Impact on Modern Thinking offers an interesting perspective on how our primitive brain functions still influence our interactions with modern technology. Understanding these primal instincts can help designers create interfaces that feel more natural and satisfying to use.

As we look to the future, it's clear that the field of user brain research is only going to become more important. The Brain Boost Search Engine: Enhancing Cognitive Performance with Digital Tools is just one example of how our growing understanding of cognitive science is being applied to create more effective digital tools.

In conclusion, designing for the user brain is not just a trend; it's a fundamental shift in how we approach user experience design. By understanding and applying cognitive science principles, we can create digital experiences that feel intuitive, engaging, and even delightful to use.

The relationship between cognitive science and UX design is evolving rapidly, with new insights and technologies constantly emerging. As designers, it's our responsibility to stay informed about these developments and to continually refine our approach to creating user-centered experiences.

So, what's the call to action for designers? It's simple: prioritize user brain considerations in every aspect of your design process. From the initial concept to the final polish, always ask yourself: "How does this align with the user's cognitive processes?" By doing so, you'll not only create more effective and engaging interfaces but also contribute to a digital world that works in harmony with our minds rather than against them.

Remember, great design isn't just about making things look good – it's about making them feel right. And that feeling comes from a deep understanding of the most complex and fascinating interface of all: the human brain.

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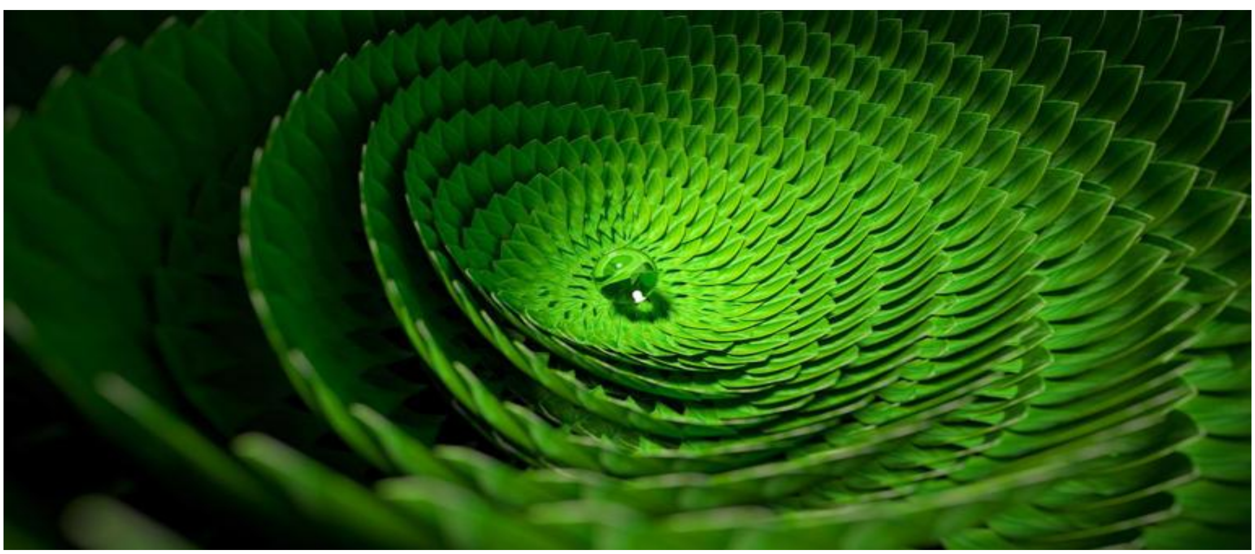
Mathematicians Have Discovered the Secret Geometry of Life



From the spirals of shells to the layout of cells, a new class of shapes redefines nature's complexity.© Andriy Onufriyenko - Getty Images

- Mathematicians show "soft cell" shapes are abundant in natural world.

- Soft cells are described as natural tiles with curved edges—a stark contrast to the mathematical solutions for creating tiling shapes.
- The soft cells then smoothly deform into tiles and work in both two and three dimensions.

A team of researchers revealed how theoretical mathematical concepts take on a real-world life when discovering a completely new "soft cell" shape that crossed over from mathematical possibility to abundant natural example.

Mathematicians have long enjoyed the study of shapes. Using sharp edges and plenty of points, they've dedicated centuries to seeing just how these shapes fit together for infinite tiling ability. But the equations used in mathematical shaping, with their hard lines and sharp points, don't generally lead to a lot of crossover with nature.

A team of researchers from Budapest University of Technology recently announced that they have uncovered a new natural class of shape that tiles with curved edges. They uploaded their findings to the preprint server *arXiv*. Dubbed both "soft cells" and "z-cells," these shapes lack the telltale corners of theoretical math, but still fit together in both two dimensions and three dimensions.

"A central problem of geometry is the tiling of space with simple structures," the authors wrote. "The classical solutions, such as triangles, squares, and hexagons in the plane and cubes and other polyhedral in three-dimensional space are built with sharp corners and flat faces. However, many tilings in nature are characterized by shapes with curved edges, non-flat faces, and few, if any, sharp corners. An important question is then to relate prototypical sharp tilings to softer natural shapes."

The team believes that they've solved the problem of dimensions with this new "infinite class of polyhedral tilings" that can smoothly deform into soft tiles and construct soft versions of cells generally associated with point lattices in both two and three dimensions.

"These shapes emerge in art, but also in biology," study lead Gabor Domokos, told the *New Scientist*. "If you look at sections of muscle tissue, you'll see the cells having just two sharp corners, which is one less than the triangle—it is a very special kind of tiling."

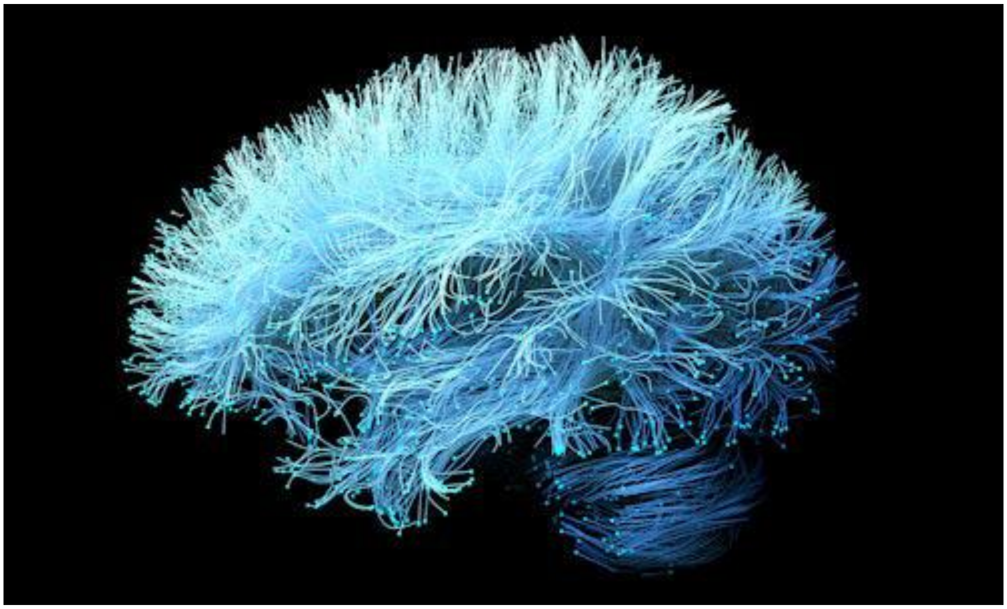
“Remarkably, these ideal soft shapes, born out of geometry, are found abundantly in nature, from cells to shells,” the team wrote.

In two dimensions, these soft shell shapes are pretty easy to describe—according to the paper, they are “cells with curved boundaries which have only two corners.” In the three-dimensional space, things get a little more complicated, but the goal is the same: let things be bendy and minimize the amount of “corners” present. In 3D, a soft cell shape can have no corners at all.

“We found that architects have found these kinds of shapes intuitively when they wanted to avoid corners,” Domokos said.

A central part of the paper shows how seashells emerge as a natural example of the shape. Known to form from multiple chambers, shell growth appears to follow a regulated pattern. Using a CT scanner, the team found that when they measured the shells in three dimensions, they couldn’t find corners, even though a two-dimensional view of the shell looked different. That led the team to believe that a seashell offers the prime example of the soft cell shape. It also shows how nature is far beyond our current understanding of geometry.

Brain Scans Of Jazz Musicians Could Unlock The Mystery Of Creative Flow



Flow, or being “in the zone,” is a state of amped-up creativity, enhanced productivity, and blissful consciousness that, some psychologists believe, is also the secret to happiness. It’s considered the brain’s fast track to success in business, the arts, or any other field.

However, in order to achieve flow, a person must first develop a strong foundation of expertise in their craft. That’s according to a new neuroimaging study from Drexel University’s Creativity Research Lab, which recruited Philly-area jazz guitarists to better understand the key brain processes that underlie flow. Once expertise is attained, the study found that this knowledge must be unleashed and not overthought in order for the flow to be reached.

As a cognitive neuroscientist who is the senior author of this study and a university writing instructor, we are a husband-and-wife team who collaborated on a book about the science of creative insight. We believe that this new neuroscience research reveals practical strategies for enhancing, as well as elucidating, innovative thinking.

Jazz musicians in flow

The concept of flow has fascinated creative people ever since pioneering psychological scientist Mihály Csíkszentmihályi began investigating the phenomenon in the 1970s.

Yet, a half-century of behavioral research has not answered many basic questions about the brain mechanisms associated with the feeling of effortless attention that exemplifies flow.

The Drexel experiment pitted two conflicting theories of flow against each other to see which better reflects what happens in people's brains when they generate ideas. One theory proposes that flow is a state of intensive hyperfocus on a task. The other theory hypothesizes that flow involves relaxing one's focus or conscious control.

The team recruited 32 jazz guitarists from the Philadelphia area. Their level of experience ranged from novice to veteran, as quantified by the number of public performances they had given. The researchers placed electrode caps on their heads to record their EEG brain waves while they improvised chord sequences and rhythms that were provided to them.

Jazz improvisation is a favorite vehicle for cognitive psychologists and neuroscientists who study creativity because it is a measurable real-world task that allows for divergent thinking – the generation of multiple ideas over time.

The musicians themselves rated the degree of flow that they experienced during each performance, and those recordings were later played for expert judges who rated them for creativity.

Train intensively, then surrender

As jazz great Charlie Parker is said to have advised, "You've got to learn your instrument, then, you practice, practice, practice. And then, when you finally get up there on the bandstand, forget all that and just wail."

This sentiment aligns with the findings of the Drexel study. The performances that the musicians self-rated as high inflow were also judged by the outside experts as more creative. Furthermore, the most experienced musicians rated themselves as being in flow more than the novices, suggesting that experience is a precondition for flow. Their brain activity revealed why.

The musicians who were experiencing flow while performing showed reduced activity in parts of their frontal lobes, which are known to be involved in executive function or cognitive control. In other words, flow was associated with relaxing conscious control or supervision over other parts of the brain.

When the most experienced musicians performed while in a state of flow, their brains showed greater activity in areas known to be involved in hearing and vision, which makes sense given that they were improvising while reading the chord progressions and listening to rhythms provided to them.

In contrast, the least experienced musicians showed very little flow-related brain activity.

Flow vs. nonflow creativity

We were surprised to learn that flow-state creativity is very different from nonflow creativity.

Previous neuroimaging studies suggested that ideas are usually produced by the default-mode network, a group of brain areas involved in introspection, daydreaming, and imagining the future. The default-mode network spews ideas like an unattended garden hose spouts water without direction. The aim is provided by the executive-control network, residing primarily in the brain's frontal lobe, which acts like a gardener who points the hose to direct the water where it is needed.

Creative flow is different: no hose, no gardener. The default mode and executive control networks are tamped down so that they cannot interfere with the separate brain network that highly experienced people have built up for producing ideas in their field of expertise.

For example, knowledgeable but relatively inexperienced computer programmers may have to reason their way through every line of code. Veteran coders, however, tapping their specialized brain network for computer programming, may just start writing code fluently without overthinking it until they complete – perhaps in one sitting – a first-draft program.

Coaching can be a help or hindrance

The findings that expertise and the ability to surrender cognitive control are key to reaching flow are supported by a 2019 study from the Creativity Research Lab. For that study, jazz musicians were asked to play “more creatively.” Given that direction, the nonexpert musicians were indeed able to improvise more creatively. That is apparently because their improvisation was largely under conscious control and could, therefore, be adjusted to meet the demand. For example, during debriefing, one of the novice performers said, “I wouldn’t use these techniques instinctively, so I had to actively choose to play more creatively.”

On the other hand, the expert musicians, whose creative process was baked in through decades of experience, were not able to perform more creatively after being asked to do so. As one of the experts put it, “I felt boxed-in, and trying to think more creatively was a hindrance.”

The takeaway for musicians, writers, designers, inventors, and other creatives who want to tap into flow is that training should involve intensive practice followed by learning to step back and let one’s skill take over. Future research may develop possible methods for releasing control once sufficient expertise has been achieved.

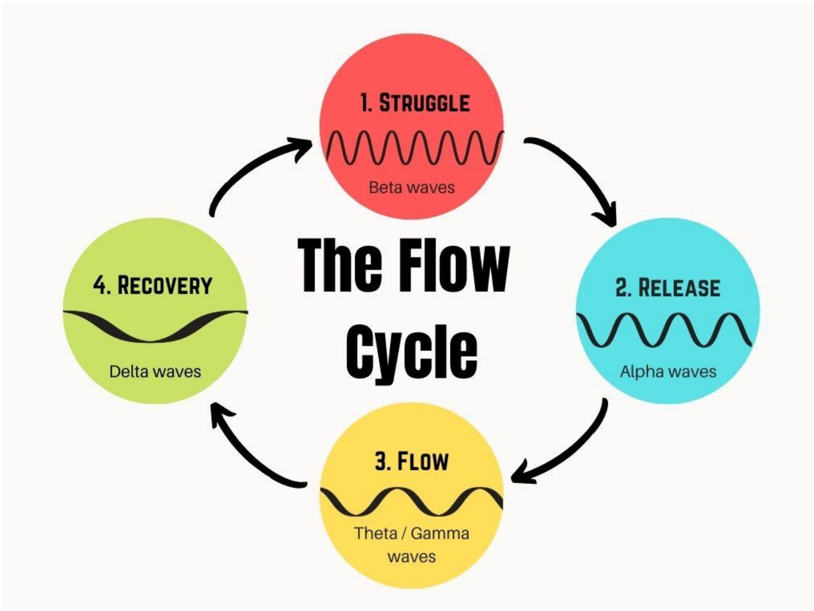
Hacking The Flow Cycle: Brainwaves, Creativity and Flow States

Everything you do and think is going to show up in your brain somehow. When you’re frustrated, when you learn a language, move your arm, or fall in love, there will be some neurons, and brain regions will light up.

This is also the case when we enter a flow state. When we start to perform at our best, when we lose our sense of time, when our inner critic goes quiet and our attention consumed, we can look inside the brain to see what’s going on in a less subjective, more physical sense.

In doing so, we might be able to get a greater understanding of the benefits of flow and how we can achieve it. While there is still a lot to learn, we know that different stages of flow in what’s called the Flow Cycle with their own unique signature of brain waves and neurotransmitter activity.

The Flow Cycle:



Flow states that result in feelings of selflessness, timelessness, effortlessness and richness tend to show up in low alpha and high theta brainwave states.

Here's how to apply the Flow Cycle to get into more flow states in your challenging activities:

1. The Struggle

When we first attempt to learn something or solve a difficult problem, consciousness is fully involved and there is often a feeling of frustration, difficulty, and stress. We're unlikely to enter flow as our abilities are not where they need to be, rather, we are overwhelmed by how much we need to absorb and process.

At this initial stage adrenaline and cortisol are often present, raising our heart rate and blood pressure, dilating our pupils and preparing the body to deal with a stressful situation. At this point your brain waves are in the BETA range of 12-40 Hz.

"When the brain is aroused and actively engaged in mental activities, it generates beta waves. These beta waves are of relatively low amplitude, and are the fastest of the different brainwaves," writes American creativity researcher Ned Herrmann.

2. The Release

After struggling for a while it's necessary to put the problem away, think about something else, take a break and give the mind a chance to reset. Doing so allows the stress hormones from the struggle phase to be flushed out, so to speak.

At this point, our brain waves sink down to ALPHA levels of 8-12 Hz. Ned Herrmann continues, "Alpha brainwaves are slower, and higher in amplitude. … A person who has completed a task and sits down to rest is often in an alpha state. A person who takes time out to reflect or meditate is usually in an alpha state."

3. The Flow State

When we make another attempt at the problem, our experience from the first stage gives us an extra edge, and we overcome the challenge by entering the zone. The difficulty of the challenge is reduced as our abilities have grown, and we hit the sweet spot where our attention is fully absorbed.

During flow, our brain is swamped with endorphins, which dull pain and give us a euphoric feeling. Meanwhile, dopamine motivates us and ensures our focus remains on the task at hand. The brain sits on the border of alpha and theta ranges, about 8 Hz.

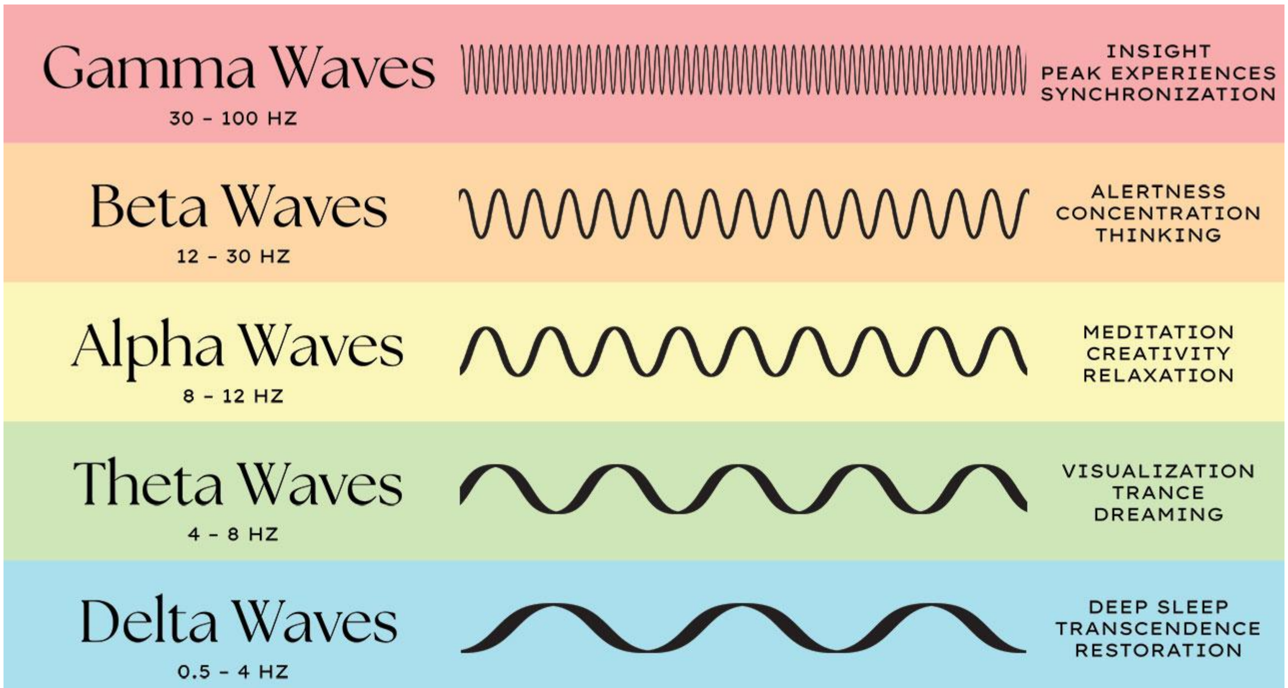
4. The Recovery

After the flow experience, our mind returns to an awareness of everything else, our sense of time and space come back, and we bask in the afterglow—the sense of reward. Serotonin is released which signals that our rush is coming to an end. Feel-good neurochemicals such as oxytocin come in.

Like most good things, we can have too much of the flow state. Rest and recovery are necessary. When we come down we might just feel like we want to go back up, making recovery easily neglected.

A Map of the 5 Brainwave Frequencies:

Here are all of our 5 major brainwave frequencies together, all-of-which are involved at different stages of the Flow Cycle.



Spikes in Creativity

Something else can happen when we're going through these stages—we can experience creative insight. When our brain gets down into low alpha or theta waves, our unconscious mind largely takes over.

"It is a state where tasks become so automatic that you can mentally disengage from them. The ideation that can take place during the theta state is often free flow and occurs without censorship or guilt," says Ned Herrmann.

During this theta activity, something called transient hypofrontality can occur, in which the front area of our brain lowers in activity. The frontal lobes are where logic and reason generally take place, so we can see that without this function we are more likely to rely on intuition and gut impulse, and it's going to make it easier to think outside the box.

It's in the theta zone of activity that particular spikes can happen which have been associated with creative insights. These spikes are in the gamma range, somewhere above 30 Hz. "The interesting thing about a gamma spike," says mental performance specialist Leslie Sherlin, "is that it always happens inside of theta oscillations. The two waves are coupled. It makes sense. Theta processes novel incoming stimuli; gamma is what happens when those stimuli snap together into new ideas."

When our frontal lobes stop exerting such an influence on us, and the rest of the brain sinks into theta waves, we are more likely to arrive at unusual solutions to those problems we had trouble overcoming with the initial investment of cognitive effort.

This is why we get some of those insights when we're doing seemingly mindless activities like washing the dishes or having a shower, and it's likely the reason we can achieve creative insights much more during flow than by analytical thinking alone.

How Theta Waves Boost Your Intuition & Creativity and How to Generate Them

Brain waves are a measurement of neural activity in our brain. Our brains

produce several types of waves, so why are scientists and psychologists so interested in theta waves?

Before we delve into theta waves, let's quickly explore the five types of brainwaves. **When we perform certain actions the neurons in our brains communicate with each other in an electrical or chemical way**. This activity can be measured in the form of frequencies or brainwaves.

5 Types of Brainwaves

1. Gamma – Concentration, insight, peak focus
2. Beta – Day-to-day, alert, learning
3. Alpha – Relaxing, daydreaming, winding down
4. Theta – Dreaming, flow states, meditation
5. Delta – Deep sleep, restorative healing sleep

We produce gamma brainwaves at moments of peak performance, or expanded consciousness. Beta brainwaves are what we experience on a daily basis during our normal routine.

Alpha waves occur when we get ready for bed, or wake up in the morning, those moments of drowsiness. Delta waves are linked with the healing processes that come with very deep sleep. So what about theta waves?

What Are Theta Waves?

If you imagine each of our five brainwaves is a gear on a car engine, then delta is the slowest gear and gamma is the highest. However, theta is number 2, so it is still pretty slow. **We experience theta waves when our minds wander off, we go on auto-pilot, we fantasize about the future, and when we daydream**.

Examples of Theta Waves in Normal Activity

- Driving home from work and when you arrive, you cannot remember any details of the journey.
- Brushing your hair and you come up with an innovative idea to solve a problem at work.
- You are immersed in a task and you feel completely in the moment.

These are all theta waves in action. Theta waves occur in many situations. However, **they are most associated with internal focus, relaxation, meditation and attaining a flow state of mind**. Now, this is what makes them interesting to psychologists and scientists. Because if we can somehow generate theta waves ourselves, we can tap into all this potential.

Brainwave entrainment is a way of stimulating the brain to enter a certain state by using specific sounds, pulses or beats. When the brain picks up these pulses, it naturally aligns to the same frequency.

"Brainwave training is a relatively new research area, but more and more labs are interested in understanding brainwaves and how they relate to a whole plethora of behaviors—from managing stress to full-blown spiritual awakenings," Leigh Winters MS neuroscientist, Columbia University's Spirituality Mind Body Institute

Benefits of Theta Waves

So why would you want to make more theta waves in the first place? Here are ten reasons why theta waves are so beneficial:

1. They relax the mind and body
2. Increase creativity
3. Empower learning skills

4. Lower the heartbeat
5. Improve problem-solving
6. Hone intuition skills
7. Better emotional connections
8. Form a connection with our subconscious mind
9. Program the unconscious mind
10. Increase our spiritual connection

I'd like to focus on the first three benefits of theta waves.

Relaxation

If you are an anxious person prone to worry and stress, then being able to instantly calm and relax is very appealing. Imagine how it would feel to enter a tranquil state? Or how it would help you slip off to sleep when your thoughts are racing?

People with phobias, those with OCD, eating disorders, you name it. Anyone that feels anxiety or stress, if they had the chance of just feeling a little more relaxed, **it could help free them from a restrictive behaviour**.
"It seems to have a tranquillizing effect for individuals who are quite anxious and high-strung. It tends to quiet them down for three to four days after a session" Dr. Thomas Budzynski

Creativity

There is evidence that suggests people who produce more theta waves report having more ideas and feeling more creative. In one study, students were wired up to a monitor to analyse their brainwaves whilst they were trying to solve a difficult problem.
It was discovered that "during the chance moment in which a difficult... concept suddenly 'made sense' (the subject) showed an abrupt change in brain wave patterns... in the theta range..."

So if you want to increase your creative output, the answer is simple, just **learn how to generate theta waves**.

Learning

One interesting aspect of theta waves is that they are generated when we are operate on autopilot. **As a result, this gives us a chance for unbiased and uncritical learning.**
What I mean by that is, we all have beliefs and opinions about ourselves that may be holding us back in some way. For example, we might think we are not good enough for college or university. That we don't deserve to make a lot of money or we shouldn't pursue a career in the arts for instance.

When we are in a theta wave state, all of these prejudices and concerns are absent. We see ourselves in an uncritical manner and this allows us to reach our full potential.

How to Make Your Brain Generate Theta Waves

Binaural Beats

It is not easy to generate theta waves yourself as it does take some amount of practice. **There are some experts that suggest the best way is to listen to specially prepared music**. These are binaural beats. Two slightly different ranges of hertz are played in each ear.

For example, if you play 410Hz in one ear and 400Hz in the other, your brain will align with the 10Hz frequency. Theta waves run from 4-8 Hertz. However, if you want to tackle one of the three areas listed above, there are different levels that target these areas.

- 5-6Hz – relaxation
- 7-8Hz – creativity and learning

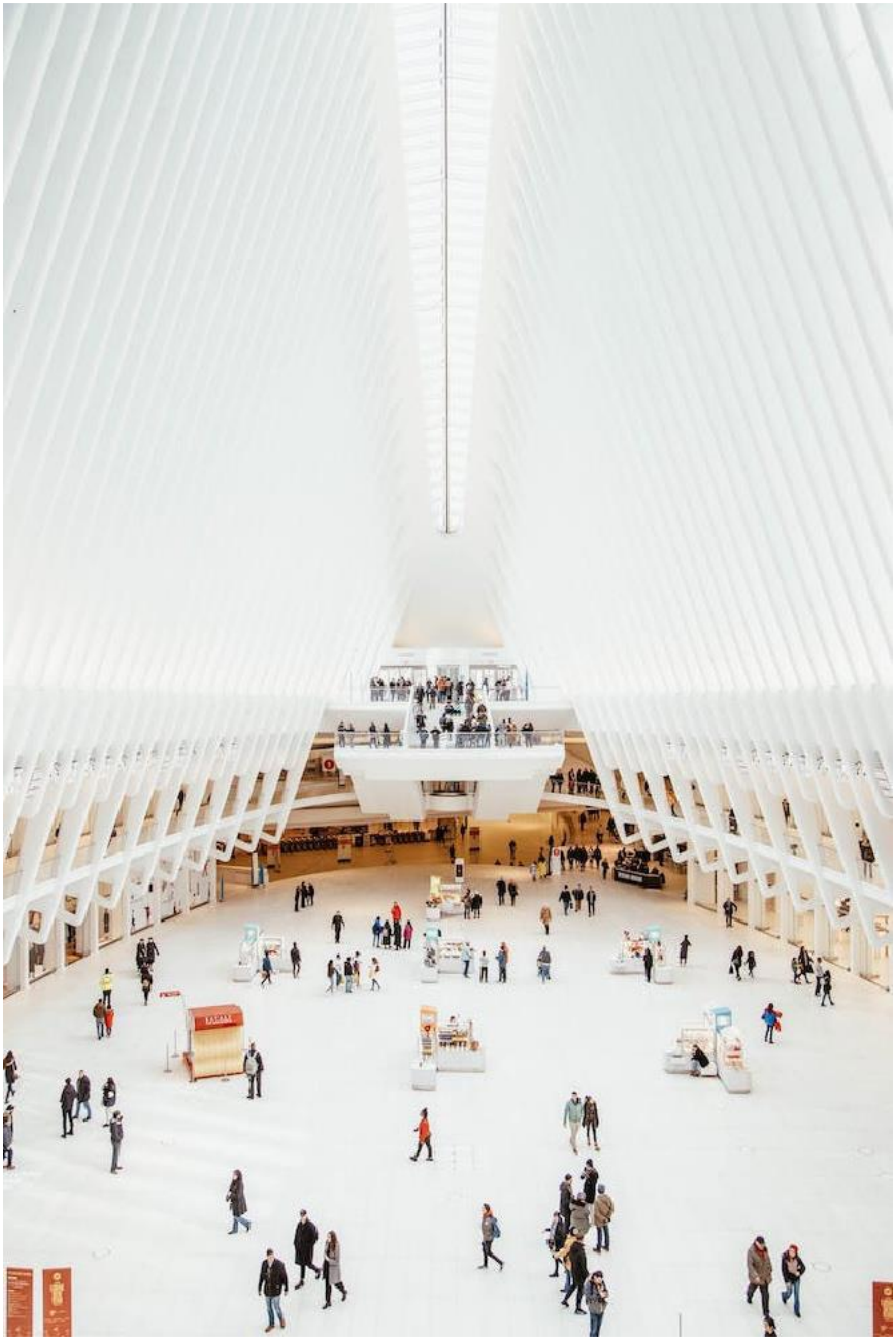
“Theta activity was induced by a 6-Hz binaural beat. Moreover, the pattern of theta activity was similar to that of a meditative state.”

Meditation

Use this method to entrain your brain to produce theta waves.

Focus on your breathing which will enable you to be in the present moment. Concentrate on the sounds around you and be aware of your surroundings. You can focus on an object or simply let your mind be still. If any thoughts come into your mind, let them drift away as you remain in the present. Feel a deep sense of relaxation, but don’t force it. You should not try and be calm, just be mindful and aware.

Researchers believe that training our own brains to produce the brainwaves we want is **the next step in our evolution**. Whatever your thoughts on the subject, it is surely a wonderful way of increasing our natural ability.



Understanding The 9 Human Design Centers: From The Head To The Root© Provided by Kelly's Thoughts On Things

Industrial Design Historical Perspective

It all started with a look at the machine's understanding of a design brief over time. The machine's first assessment was that an "industrial design brief" did not exist in the 1950s. Some rephrasing of the prompt to compact the information.

An industrial design brief is a document used to prepare for the process of designing a new item. Quote a description of "industrial design brief" or outline of the initial industrial design process, from a well-regarded book from the 1950s, cite the sources. For each book, note why it is considered well-regarded and a quote from a reviewer of the book. Repeat for each decade until 2021. title each section with the decade, and a two-word summation of the spirit, and use the H2 tags for the title text.

1950s - Pragmatic Approach

In his book "Industrial Design: A Practical Guide," William S. Mendenhall describes the initial industrial design process as "The first step is to obtain a clear understanding of the functional requirements of the product, as well as the psychological and aesthetic aspects of design." (p. 55) Mendenhall's book is considered well-regarded for its practical and pragmatic approach to industrial design.

1960s - Design for the Future

In "The Design Method," John Chris Jones writes, "The designer is not concerned with what has been but with what might be." (p. 20) Jones' book is well-regarded for its forward-thinking and revolutionary ideas about design as a problem-solving process.

1970s - User-Centered Design

In his book "The Psychology of Everyday Things," Donald A. Norman emphasizes the importance of user-centered design, stating "The real problem with the interface is that it is an interface. Interfaces get in the way. I don't want to focus my energies on an interface. I want to focus on the job." (p. xvi) Norman's book is well-regarded for its influence on the design community's focus on usability and user-centered design.

1980s - Design as a Business Strategy

Robert Blaich's book "Designing Competitive Products" emphasizes the importance of design as a business strategy, stating "Design can be the distinguishing factor that sets your products apart from the competition." (p. 8) Blaich's book is well-regarded for its focus on the strategic role of design in business.

1990s - Sustainable Design

In "The Green Imperative: Natural Design for the Real World," Victor Papanek writes, "Design must be an innovative, highly creative, cross-disciplinary tool responsive to the needs of men. It must be more research-oriented, and we must stop defiling the earth itself with poorly-designed objects and structures." (p. 11) Papanek's book is well-regarded for its influential ideas about sustainable design and the responsibility of designers to consider environmental impact.

2000s - Human-Centered Design

IDEO's "The Field Guide to Human-Centered Design" emphasizes the importance of human-centered design, stating "Human-centered design is a creative approach to problem-solving that starts with the people you're designing for and ends with new solutions that are tailor-made to suit their needs." (p. 2) The book is well-regarded for its influential role in popularizing the concept of human-centered design and its practical guidance for designers.

2010s: Design Thinking

In "Change by Design" by Tim Brown, the industrial design brief is seen as a tool for incorporating design thinking into the product development process. Brown defines design thinking as "a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success" (p. 6). The brief is used to identify the user's needs and develop insights into the problem that the design is meant to solve. This book is well-regarded for its exploration of design thinking as a methodology for innovation. A reviewer from BusinessWeek called it "a powerful new way to think about and approach business" (Sept. 28, 2009) …

Then asked for a summary. Keep in mind that each time this is generated the content changes. If you spot the machine BS'ing (as in repeated titles), or you have an overriding opinion, correct it.

Using the above sources and other books of the time, for each decade since 1950, write a one-paragraph summary of the evolution of the industrial design brief for each decade.

1950s: Industrial design briefs in the 1950s were typically focused on the aesthetic and functional aspects of a product. The briefs were often informal and left a lot of room for the designer's interpretation. There was little emphasis on ergonomics or user experience, and designs were largely driven by the needs of the manufacturer rather than the end-user.

1960s: By the 1960s, industrial design briefs had become more formalized and structured. There was a greater focus on the end-user, with an emphasis on creating products that were not only functional but also aesthetically pleasing and easy to use. Designers were encouraged to consider ergonomics and the user experience when developing new products.

1970s: In the 1970s, industrial design briefs began to include more technical specifications and requirements. There was a greater emphasis on engineering and materials science, and designers were expected to work closely with engineers to ensure that their designs could be manufactured efficiently and cost-effectively.

1980s: The 1980s saw a continued focus on technical specifications and requirements, but there was also an increased emphasis on market research and consumer behavior. Designers were expected to consider factors such as target audience, consumer preferences, and market trends when developing new products.

1990s: In the 1990s, industrial design briefs became more comprehensive and detailed. There was a greater emphasis on user-centered design and creating products that met the needs and preferences of the end-user. Designers were expected to conduct extensive research into user needs, behaviors, and preferences, and to use this information to inform their design decisions.

2000s: In the 2000s, industrial design briefs continued to evolve, with a greater emphasis on sustainability and environmental impact. Designers were expected to consider the full lifecycle of a product, from raw materials to end-of-life disposal, and to design products that minimized their environmental impact. There was also a greater focus on designing products that were intuitive and easy to use, with an emphasis on user-centered design.

2010s: In the 2010s, industrial design briefs continued to evolve with the rise of digital technology and the internet of things. Designers were expected to consider how their products would fit into a connected ecosystem of devices and services, and to design products that could seamlessly integrate with other products and services. There was also a greater emphasis on creating products that were not only functional and sustainable but also emotionally resonant, with an emphasis on design aesthetics and brand identity.

Drawing on published literature from the last 20 years. Define a bullet point structure of a classic product development or industrial design brief for a cycling helmet that explores new materials for impact mitigation, focusing on friable materials and controlled crush. Consider incorporating digital and Internet

Of Things elements in both the development and final product. Cite sources at each bullet point, use H2 tags for titles. *

Here's a bullet point structure for a product development or industrial design brief for a cycling helmet that explores new materials for impact mitigation, focusing on friable materials and controlled crush, while incorporating digital and IOT elements in both the development and final product:

Problem statement and background research

- Define the problem of traditional helmet materials and the need for new impact mitigation materials (source: Wang et al., 2021)
- Summarize research on the use of friable materials and controlled crush technology in helmet design (source: Mills et al., 2019)

Product goals and design specifications

- Establish goals for the new helmet design, such as improved impact mitigation and reduced weight (source: Skorobogatiy et al., 2018)
- Define design specifications, including specific materials to be tested and incorporated into the helmet design (source: Helmets.org, 2021)

Materials testing and prototyping

- Outline testing procedures and criteria for materials, including impact resistance and crush characteristics (source: Jayaraman et al., 2020)

- Establish a prototyping process that includes both traditional methods and digital tools, such as 3D printing (source: Papalambros et al., 2017)

Digital and IOT elements

- Explore potential digital and IOT features to be incorporated into the helmet, such as sensors that monitor impact force or temperature (source: Liu et al., 2018)
- Outline the development process for these features, including programming and data analysis (source: Alharthi et al., 2019)

User testing and evaluation

- Plan for user testing and evaluation of the new helmet design, including both objective measurements and subjective feedback from users (source: Kluth et al., 2020)
- Identify potential safety concerns and address them through further design iterations and testing (source: Attewell et al., 2001)

Sources:

- Wang, L., et al. (2021). "Design and optimization of a novel multi-layered helmet based on the energy-absorbing concept." International Journal of Impact Engineering.
- Mills, N. J., et al. (2019). "Developments in cycling helmets and head injury prevention." Journal of the Royal Society of Medicine.

- Skorobogatiy, M., et al. (2018). “Engineering and design of innovative materials for soft and hard body armor systems.” Journal of Materials Research and Technology.
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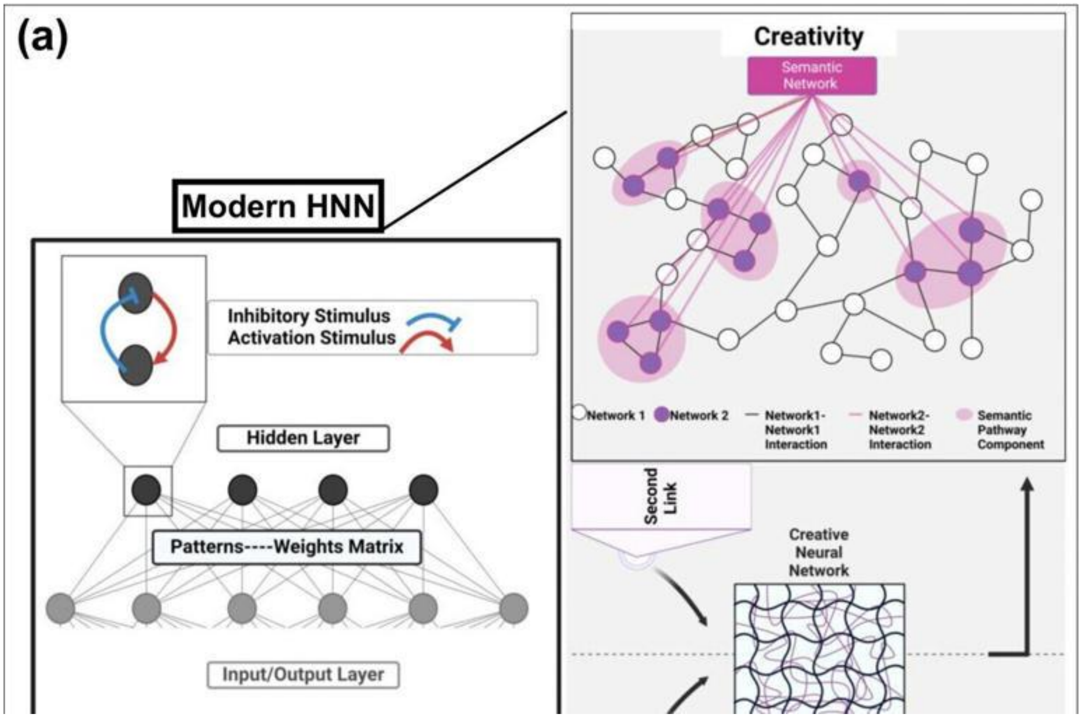
- Jayaraman, S., et al. (2020). “A review of helmet testing standards and helmet performance testing using computational simulations.” Journal of Biomechanics.
- Papalambros, P. Y., et al. (2017). “Integrated product and process design: A concurrent engineering approach.” Springer.
- Liu, Z., et al. (2018). “Design and implementation of smart helmet based on IoT.” 2018 IEEE 3rd International Conference on Image, Vision and Computing.
- Alharthi, S. S., et al. (2019). “Development of an IoT helmet for workers’ safety.” 2019 IEEE International Conference on Smart Manufacturing, Industrial & Logistics Engineering.
- Kluth, J. P., et al. (2020). “Objective and subjective evaluation of bicycle helmet design and impact attenuation properties.” Accident Analysis & Prevention.
- Attewell, R. G., et al. (2001). “Bicycle helmet efficacy: a meta-analysis.” Accident Analysis & Prevention.

Some interesting things to flesh out, but a paper I have not seen before…

Me: *summarize the concepts and materials in this paper" Wang, L., et al. (2021). “Design and optimization of a novel multi-layered helmet based on the energy-absorbing concept.” International Journal of Impact Engineering.*

The paper describes the design and optimization of a multi-layered helmet that utilizes energy-absorbing concepts for impact mitigation. The helmet is composed of several layers with different materials and thicknesses, each layer serving a specific function in energy absorption. The outer shell is made of polycarbonate, while the inner layer consists of a series of foam pads made of different materials such as expanded polystyrene (EPS), polyurethane (PU) foam, and silicone rubber. The design was optimized using finite element analysis (FEA) to achieve the best balance between energy absorption and weight. The results of the study show that the multi-layered helmet has better impact performance than a traditional helmet with a single layer of EPS foam, and can effectively reduce the risk of head injury.

Appreciate the exposition here. Noob question: if two people (say you and I) enter the same prompt, will we get the same resulting output? What about if we do it a week apart?



Summary of a hypothetical model of the simulation of the modern Hopfield neural network. Credit: The Journal of Creative Behavior (2024). DOI: 10.1002/jocb.680

Creativity is the art of combining diverse ideas, making meaningful connections between concepts, and remaining focused to produce innovative ideas and useful solutions.

Expansive and remote associations drive the generation of new ideas, while inhibition enables refining these ideas into practical solutions.

A recent study, led by former student Ronald Mtenga and directed by Dr. Mathias Bode and Dr. Radwa Khalil at Constructor University, has illuminated crucial conclusions about creative thinking processes. The study, published in the *Journal of Creative*

Behavior, provides a fresh perspective on the shift from analytical to creative thinking.

This study employed a unique approach by utilizing the Hopfield neural network (HNN), a neural network model, to investigate the mechanisms of semantic creative thinking–based associations. Researchers identified two key mechanisms that facilitate the transition from analytical to creative, associative thinking, suggesting that creative thinking often emerges when analytical thinking is insufficient.

Ronald Mtenga, the study's first author, holds a BSc in Electrical and Computer Engineering from Constructor University, where Dr. Mathias Bode is affiliated. Dr. Radwa Khalil is an expert in the creativity field, known for her multidisciplinary approaches that spans cognitive neuroscience, neuropsychology, computational modeling, and empirical research.

More information: Ronald Mtenga et al, Do Not Let the Beginning Trap you! On Inhibition, Associative Creative Chains, and Hopfield Neural Networks, *The Journal of Creative Behavior* (2024). DOI: 10.1002/jocb.680

Provided by Constructor University

Scientists are using AI to build a “periodic table of shapes” filled with Fano varieties—the basic “atomic structure” of geometry.© Eugene Mymrin - Getty Images

- Fano varieties are known as the basic “atomic structure” of geometry, but are notoriously difficult to discover and organize.
- Scientists from the Imperial College of London have been attempting to build a “periodic table of shapes” filled with these Fano varieties for more than a decade.
- In a new study, these scientists—as well as scientists from the University of Nottingham—have turned to AI and machine learning to help form this new periodic table.

Just as molecules can be broken down into atoms, so too can mathematical shapes be broken down into more basic components. These components are known as Fano varieties—named after Italian mathematician Gino Fano—and understanding them can help mathematicians make major discoveries.

There’s just one problem. Fano varieties are notoriously difficult to categorize.

That’s what scientists at the Imperial College of London discovered when they set out to create a “periodic table of shapes” more than a decade ago. Similar to how elements are grouped together with like elements on the periodic table, this geometric table aims to group related Fano varieties together. Easier said than done.

So, the Imperial team—which also includes scientists from the University of Nottingham—turned to AI and machine learning to help speed up the process. The results of this novel method were published in the journal *Nature Communications* in early September.

“Fano varieties are basic building blocks in geometry—they are ‘atomic pieces’ of mathematical shapes,” the study reads. “Our results demonstrate that machine learning can pick out structure from complex mathematical data in situations where we lack theoretical understanding. They also give positive evidence for the conjecture that the quantum period of a Fano variety determines that variety.”

These shapes are not your average, run-of-the-mill parallelograms—rather, they are complex shapes that are more spherical and without hard edges. These shapes can be described by differential equations, and if they meet certain unique “flow pattern” criteria, they’re considered “atoms.” However, multiple occurrences of these patterns means that the shape can be further broken down into smaller components.

Fano discovered the first of these "atomic" shapes back in the 1930s. More have been discovered since, but so far, they lack any organizing principle. Once categorized in a periodic table defined by a shape's unique quantum period, gaps could help tell mathematicians where new shapes could be discovered (much like what the periodic table does for chemists and physicists).

"For mathematicians, the key step is working out what the pattern is in a given problem," study co-author Alexander Kasprzyk, a professor at the University of Nottingham, said in a press statement. "This can be very difficult, and some mathematical theories can take years to discover."

Luckily, finding patterns in a large dataset is AI's specialty.

In the study, the team assigned a kind of "barcode"—the number for which was determined by the shape's features—to each shape. With 99 percent accuracy, the AI was able to discern the properties of these shapes from just the barcode alone, insinuating that grouping these shapes is a possibility. This has helped the team begin to form a periodic table of shapes by grouping similar geometric properties with one another.

In addition to being a helpful hand in crafting a periodic shape table, using AI in this way also has broader implications for mathematics as a whole. "This could be very broadly applicable, such that it could rapidly accelerate the pace at which maths discoveries are made," PhD student and study co-author Sara Veneziale said in a press statement. "It's like when computers were first used in maths research, or even calculators: it's a step-change in the way we do maths.

Sometimes, the signs that someone is smart are easily recognizable. Other giveaways are more subtle.

The top one: being a good listener, says New York-based psychotherapist and career coach Jenny Maenpaa.

People who "are able to perceive an interaction holistically, rather than just being in the moment and responding to the last thing you said with the first thing they thought of" are usually highly intelligent, Maenpaa tells CNBC Make It.

This skill is also known as active listening, and it requires more than just sitting in silence while someone speaks.

"Active listening is when someone can listen to you at length, truly taking in what you're saying, and not interrupt," Maenpaa says. "Active listeners respond with questions because they are genuinely curious about what you're saying. They can hold their questions in their mind until you finish instead of interrupting to clarify or to share a thought they had just because you reminded them of it."

Successful people can use this skill to foster relationships and build trust and with colleagues, bosses, mentors or anyone else around them. Many professionals believe that they're active listeners, but 70% of them actually exhibit poor listening habits in the workplace, resulting in misunderstandings and damaged friendships, according to a 2020 University of Southern California report.

Some people are "naturally gifted with [active listening skills] from an early age, and often receive feedback like, 'You're so easy to talk to!' or 'I feel like I'm the only person in the room when we talk,'" says Maenpaa.

Others can develop the ability through practice. Maintain eye contact with your conversation partners, sit still instead of fidgeting, and wait for people to finish their thoughts before speaking, psychologist and mental health coach Amanda O'Bryan recommended in a 2022 Positive Psychology blog post.

Internalizing what the other person is saying, rather than focusing exclusively on your own thoughts, can also help.

"Active listeners will be able to circle back to an earlier point in the conversation and say, 'What you just said reminds me of something you said a few minutes ago,' and make connections or draw themes from the conversation," Maenpaa says.

The skill can help you create long-lasting connections with the people around you, she adds: "Talking to someone who is an active listener will often have someone leaving the conversation feeling seen, heard, and validated from their interaction."

- Mathematicians show “soft cell” shapes are abundant in natural world.
- Soft cells are described as natural tiles with curved edges—a stark contrast to the mathematical solutions for creating tiling shapes.
- The soft cells then smoothly deform into tiles and work in both two and three dimensions.

A team of researchers revealed how theoretical mathematical concepts take on a real-world life when discovering a completely new “soft cell” shape that crossed over from mathematical possibility to abundant natural example.

Mathematicians have long enjoyed the study of shapes. Using sharp edges and plenty of points, they’ve dedicated centuries to seeing just how these shapes fit together for infinite tiling ability. But the equations used in mathematical shaping, with their hard lines and sharp points, don’t generally lead to a lot of crossover with nature.

A team of researchers from Budapest University of Technology recently announced that they have uncovered a new natural class of shape that tiles with curved edges. They uploaded their findings to the preprint server *arXiv*. Dubbed both “soft cells” and “z-cells,” these shapes lack the telltale corners of theoretical math, but still fit together in both two dimensions and three dimensions.

“A central problem of geometry is the tiling of space with simple structures,” the authors wrote. “The classical solutions, such as triangles, squares, and hexagons in the plane and cubes and other polyhedral in three-dimensional space are built with sharp corners and flat faces. However, many tilings in nature are characterized by shapes with curved edges, non-flat faces, and few, if any, sharp corners. An important question is then to relate prototypical sharp tilings to softer natural shapes.”

The team believes that they’ve solved the problem of dimensions with this new “infinite class of polyhedral tilings” that can smoothly deform into soft tiles and construct soft versions of cells generally associated with point lattices in both two and three dimensions.

“These shapes emerge in art, but also in biology,” study lead Gabor Domokos, told the *New Scientist*. “If you look at sections of muscle tissue, you’ll see the cells having just two sharp corners, which is one less than the triangle—it is a very special kind of tiling.”

“Remarkably, these ideal soft shapes, born out of geometry, are found abundantly in nature, from cells to shells,” the team wrote.

In two dimensions, these soft shell shapes are pretty easy to describe—according to the paper, they are “cells with curved boundaries which have only two corners.” In the three-dimensional space, things get a little more complicated, but the goal is the same: let things be bendy and minimize the amount of “corners” present. In 3D, a soft cell shape can have no corners at all.

“We found that architects have found these kinds of shapes intuitively when they wanted to avoid corners,” Domokos said.

A central part of the paper shows how seashells emerge as a natural example of the shape. Known to form from multiple chambers, shell growth appears to follow a regulated pattern. Using a CT scanner, the team found that when they measured the shells in three dimensions, they couldn’t find corners, even though a two-dimensional view of the shell looked different. That led the team to believe that a seashell offers the prime example of the soft cell shape. It also shows how nature is far beyond our current understanding of geometry.

The beauty of maths: Fibonacci and the Golden Ratio

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Have you ever heard of the Fibonacci sequence? Or the Golden Ratio? Or the Golden Spiral?

These mysterious numbers and shapes are all connected to each other. If you look closely, they can be found in the most unexpected of places, creating beautiful and pleasing patterns.

Put simply, the Fibonacci sequence is a series of numbers which begins with 1 and 1. From there, you add the previous two numbers in the sequence together, to get the next number. This is a type of *recursive sequence*.

So 1+1=2, 1+2=3, 2+3=5, and so on. This gives you a sequence that looks like 1, 1, 2, 3, 5, 8, 13, 21, 34, 55 etc. But what makes this sequence so special and interesting?

Image caption,
Fibonacci numbers appear in the number of spirals in Romanesco Broccoli

The mathematical sequence that governs nature

For starters, Fibonacci numbers can be found in the natural world all around us. Most flowers, for example, will have a number of petals which correspond with the Fibonacci sequence. Irises have three petals whereas wild roses and buttercups have five petals. That is of course, until a petal falls off. No wonder rare four leaf clovers are seen as lucky!

If you cut into a piece of fruit, you're likely to find a Fibonacci number there as well, in how the sections of seeds are arranged. Bananas have three sections whilst apples have five.

The Fibonacci sequence even plays a role in the subtle spirals you can see in the seed head of a sunflower. This is because of something known as the Golden Ratio, the Golden Section or the Greek letter Phi. If you take a number in the sequence above 5, and divided it by the previous number, you will get an answer very close to 1.618. The larger the numbers, the closer you get to 1.618. The Golden Ratio is an irrational number, and so cannot be written as a fraction. Again, this is a number that can be found the natural world.

Take the sunflower. To be as efficient as possible, its seeds need to be closely packed together without overlapping. Now, if it simply grew seeds in a straight line in one direction, that would leave loads of empty space on the flower head. The best way of minimising wasted space is for the seeds to grow in spirals, with each seed growing at a slight angle away from the previous one.

If the degree of turn was a fraction, like 1/4, that doesn't help matters much because after four turns the seed pattern would be right back at the start again. There would be four lines of seeds, but that's not much better than one when trying to cover a circular area. The perfect degree of turn needs to be an irrational number, which can't be easily approximated by a fraction, and the answer is the Golden Ratio.

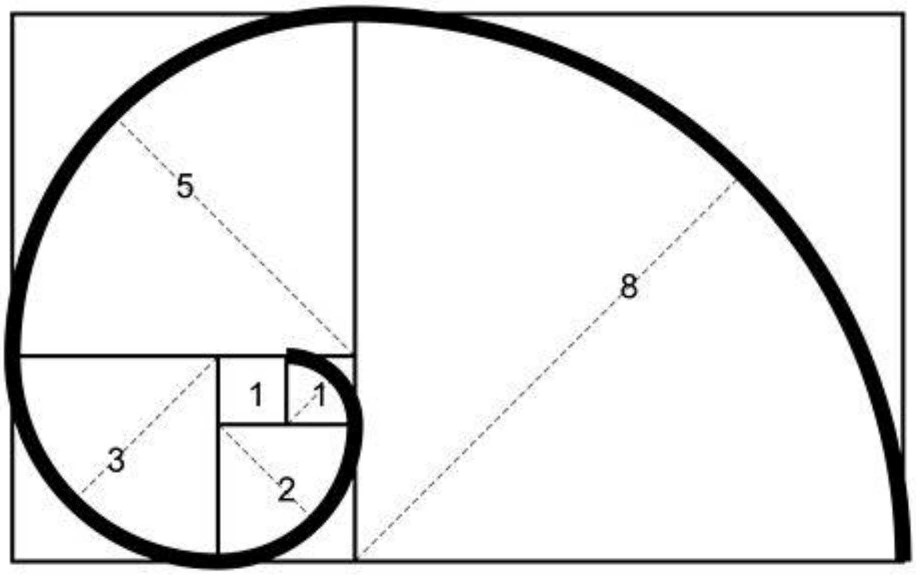

Image caption,
The Fibonacci Spiral can be found in art, architecture, biology and many more places

Transforming numbers into an eye-catching spiral

Another way of thinking about the Golden Ratio is as a spiral. This spiral gets wider by a factor of 1.618 every time it makes a quarter turn (90°).

Drawing a perfect Golden Spiral is pretty tricky to do by hand, but just like with the Golden Ratio, you can get a close approximation with the Fibonacci Spiral. This is created by drawing an arc through a series of squares which correspond to the Fibonacci numbers, so 1^2, 1^2, 2^2, 3^2 etc.

You might have seen these spirals superimposed over famous pieces of artwork, as experts try and explain why we find them so aesthetically pleasing. Often, the spiral draws in our eye so that the focus of the artwork is found in the centre of the spiral. Examples can be found in the **works of Leonardo da Vinci** and Salvador Dali.

Listening for the Fibonacci sequence in music

Fibonacci didn’t actually discover the sequence himself. Born Leonardo Bonacci in 12th-Century Pisa, Italy, the mathematician travelled extensively around North Africa. There, he learnt how the Hindu-Arabic numerals of 0-9 could be used to complete calculations more easily than the Roman numerals still in use across much of Europe. Fibonacci explained his findings in a book called Liber Abaci, published in 1202, which had a section devoted to the intriguing sequence which would be named after him hundreds of years later.

Indian poets and musicians had already been aware of the Fibonacci sequence for centuries though, having spotted its implications for rhythm and different combinations of long and short beats.

Mozart made use of the Golden Ratio when writing a number of his piano *sonatas*. A sonata can be divided into two separate sections, known as the exposition (where the *theme* is introduced) and the development and recapitulation (where the theme is developed and repeated). In Mozart’s sonatas, the number of bars of music in the latter section divided by the former is approximately 1.618, the Golden Ratio.

There’s even a style of poetry inspired by the Fibonacci sequence, known as Fib Poetry. Every line of the poem must contain the exact number of syllables that correspond with the Fibonacci sequence. So a six line poem would have syllable line counts of 1, 1, 2, 3, 5 and 8.

Golden Ratio Explained: How to Calculate the Golden Ratio

Written by MasterClass

Last updated: Jun 7, 2021 • 2 min read

The golden ratio is a famous mathematical concept that is closely tied to the Fibonacci sequence.

What Is the Golden Ratio?

The golden ratio or golden mean, represented by the Greek letter phi (ϕ), is an irrational number that approximately equals 1.618. The golden ratio results when the ratio of two numbers is the same as the ratio of their sum to the larger of the two numbers. In other words, the golden ratio occurs when you divide a line segment into two smaller segments of different lengths for which the ratio of the whole line segment to the longer segment is equal to the ratio of the longer segment to the shorter segment.

A Brief History of the Golden Ratio

The golden ratio is a special number, and its story begins with the ancient greeks.

1. 1. **300 BC**: Greek mathematician Euclid provided the first written definition of the golden ratio in his math textbook *Elements*. At the time, Euclid called it the "extreme and mean ratio."
2. 2. **1509 AD**: Italian mathematician Luca Paciolifurther used the golden proportion to describe the natural world in his book *De Divina Proportione* (*On the Divine Proportion*), which was illustrated by Leonardo da Vinci.
3. 3. **1835**: German mathematician Martin Ohm first described the ratio as "golden" when he used the term *goldener schnitt*, which translates to "golden section."
4. 4. **1910**: American mathematician Mark Barr first used the Greek letter phi (ϕ) to represent the golden ratio.

How to Calculate the Golden Ratio

The golden ratio occurs when you take a line segment and divide it into two smaller segments of different lengths where the ratio of the whole line segment to the longer segment is equal to the ratio of the longer segment to the shorter segment. Two quantities a and b have a golden ratio relationship if

$$\frac{a+b}{a} = \frac{a}{b} = \varphi$$

where a > b > 0 and the Greek letter phi (ϕ) represents the golden ratio. The golden ratio expressed numerically is

$$\varphi = \frac{1+\sqrt{5}}{2} = 1.6180339887...$$

Since the number phi is irrational, the digits after the decimal point continue on forever without repeating.

Golden Ratio and the Fibonacci Sequence

The golden ratio is closely connected to the Fibonacci sequence. This is because as the Fibonacci numbers increase, the ratio of any two consecutive Fibonacci numbers gets closer and closer to the golden ratio.

The Golden Ratio in the Real World

The below examples of the golden ratio are exceptions rather than rules—in general, claims that the golden ratio appears throughout art, architecture, nature, and the human body are overstated. However, the golden ratio does feature prominently in a few natural and manmade examples.

- **In plants**: You can find the golden ratio in the spiral arrangement of leaves (called a phyllotaxis) on some plants, or in the golden spiral pattern of pinecones, cauliflower, pineapples, and the arrangement of seeds in sunflowers.

- **In art**: Within the last century, artists have been inspired by the aesthetics of the golden ratio and incorporated it into their works. For example, the canvas of surrealist painter Salvador Dali's *The Sacrament of the Last Supper* is a golden rectangle, and the painting itself features a giant dodecahedron with edges in the golden ratio.
- **In architecture**: The Parthenon in Greece incorporates the golden ratio in many of its design elements. In the twentieth century, Swiss architect Le Corbusier used the golden ratio in his Modulor system for the scale of architectural proportion. The United Nations Secretariat Building in New York City was designed using the golden ratio: the size and shape of the windows, columns, and some sections of the building are based on the golden ratio.

3 Questions: Inverting the problem of design

MIT and IBM researchers are creating linkage mechanisms to innovate human-AI kinematic engineering.

Lauren Hinkel | MIT-IBM Watson AI Lab

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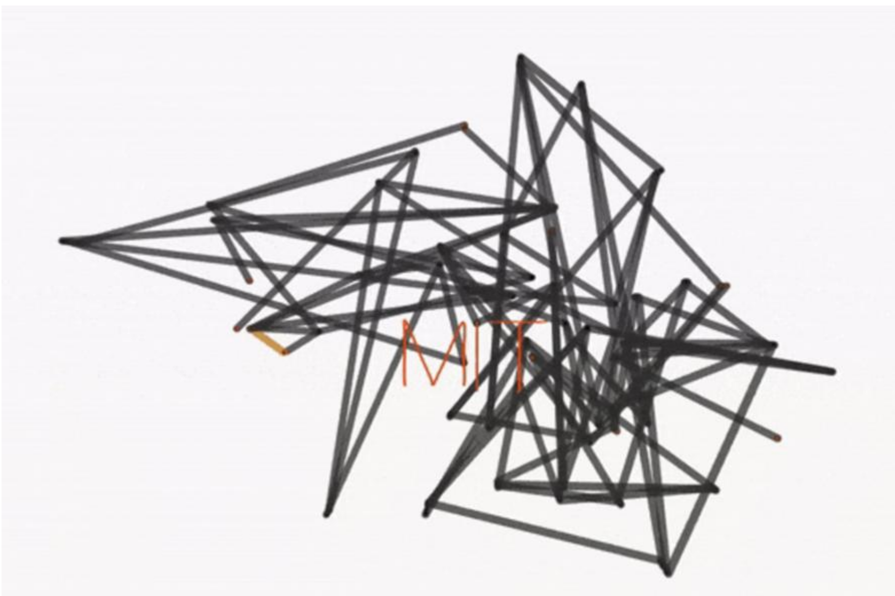

Caption:
The Linkages framework learns ways to trace curves.
Credits:
Image courtesy of the authors.

The process of computational design in mechanical engineering often begins with a problem or a goal, followed by an assessment of literature, resources, and systems available to address the issue. The Design Computation and Digital Engineering (DeCoDE) Lab at MIT instead explores the bounds of what is possible.

Working with the MIT-IBM Watson AI Lab, the group's lead, ABS Career Development Assistant Professor Faez Ahmed, and graduate *student Amin Heyrani Nobari in the Department of Mechanical Engineering are combining machine learning and generative AI techniques, physical modeling, and engineering principles to tackle design challenges and enhance the creation of mechanical systems. One of their projects, Linkages, investigates ways planar bars and joints can be connected to trace curved paths. Here, Ahmed and Nobari describe their recent work.*

Q: How is your team considering approaching mechanical engineering questions from the standpoint of observations?

Ahmed: The question we have been thinking about is: How can generative AI be used in engineering applications? A key challenge there is incorporating precision into generative AI models. Now, in the specific work that we have been exploring there, we are using this idea of self-supervised contrastive learning approaches, where effectively we are learning these linkage and curve representations of design, or what the design looks like, and how it works.

This ties very closely with the idea of automated discovery: Can we actually discover new products with AI algorithms? Another comment on the broader picture: one of the key ideas, specifically with linkages, but broadly around generative AI and large language models — all of these are the same family of models that we are looking at, and precision really plays a big role in all of them. So, the learnings we have from these types of models, where you have, in some form of data-driven learning assisted by engineering simulators and joint embeddings of design, and performance — they can potentially translate to other engineering domains also. What we are showing is a proof of concept.

Then people can take it and design ships and aircraft, and precise image generation problems, and so on.

In the case of linkages, your design looks like a set of bars and how they are connected. How it works is basically the path they would transcribe as they move, and we learn these joint representations. So, there's your primary input — somebody will come and draw some path — and you're trying to generate a mechanism that can trace that. That enables us to solve the problem in a much more precise way and significantly faster, at 28 times less error (more accurate) and 20 times faster than prior state-of-the-art approaches.

Q: Tell me about the linkages method and how it compares to other similar methods.

Nobari: The contrastive learning happens between the mechanisms, which are represented as graphs, so basically, each joint will be a node in a graph and the node will include some features. The features are the position, the space, and the type of joints, it can be that they're fixed joints or free joints.

We have an architecture that takes into account some of the basic underlying things when it comes to the description of the kinematics of a mechanism, but it's essentially a graph neural network that computes embeddings for these mechanism graphs. Then, we have another model that takes as inputs these curves and creates an embedding for that, and we connect these two different modalities using contrastive learning.

Then, this contrastive learning framework that we train is used to find new mechanisms, but obviously we care about precision as well. On top of any candidate mechanisms that are identified, we also have an additional optimization step, where these mechanisms that are identified will be further optimized to get as close as possible to those target curves.

If you've got the combinatorial part right, and you're quite close to where you need to be to get to the target curve that you have, you can do the direct gradient-based optimization and adjust the position of the joints to get super-precise performance on it. That's a very important aspect of it to work.

These are the examples of the letters of alphabet, but these are very hard to achieve traditionally with existing methods. Other machine learning based methods are often not even able to do this kind of thing because they are only trained on four bars or six bars, which are very small mechanisms. But what we've been able to show is that even with relatively small number of joints, you can get very close to those curves.

Before this, we didn't know what the limits of design capabilities were with a single linkage mechanism. It's a very hard question to know. Can you really write the letter M, right? No one has ever done that, and the mechanism is so complex and so rare that it's finding a needle in the haystack. But with this method, we show that it is possible.

We've looked into using off-the-shelf generative models for graphs. Generally, generative models for graphs are very difficult to train, and they're usually not very effective, especially when it comes to mixing continuous variables that have very high sensitivity to what the actual kinematics of a mechanism will be. At the same time, you have all these different ways of combining joints and linkages. These models simply just cannot generate effectively.

The complexity of the problem, I think, is more obvious when you look at how people approach it with optimization. With optimization, this becomes a mixed-integer, nonlinear problem. Using some simple bi-level optimizations or even simplifying the problem down, they basically create approximations of all the functions, so that they can use mixed-integer conic programming to approach the problem. The combinatorial space combined with the continuous space is so big that they can basically go up to seven joints. Beyond that, it becomes extremely difficult, and it takes two days to create one mechanism for one specific target. If you were to do this exhaustively, it would be very difficult to actually cover the entire design space. This is where you can't just throw deep learning at it without trying to be a little more clever about how you do that.

The state-of-the-art deep learning-based approaches use reinforcement learning. They — given a target curve — start building these mechanisms more or less randomly, basically a Monte Carlo optimization type of approach. The measure for this is directly comparing the curve that a mechanism traces and the target curves that are input to the model, and we show that our model performs like 28 times better than that. It's 75 seconds for our approach, and the reinforcement learning-based approach takes 45 minutes. The optimization approach, you run it for more than 24 hours, and it doesn't converge.

I think we have reached the point where we have a very robust proof of concept with the linkage mechanisms. It's a complicated enough problem that we can see conventional optimization and conventional deep learning alone are not enough.

Q: What's the bigger picture behind the need to develop techniques like linkages that allow for the future of human-AI co-design?

Ahmed: The most obvious one is design of machines and mechanical systems, which is what we've already shown. Having said that, I think a key contribution of this work is that it's a discrete and continuous space that we are learning. So, if you think about the linkages that are out there and how the linkages are connected to each other, that's a discrete space. Either you are connected or not connected: 0 and 1, but where each node is, is a continuous space that can vary — you can be anywhere in the space. Learning for these discrete and continuous spaces is an extremely challenging problem. Most of the machine learning we see, like in computer vision, it's only continuous, or language is mostly discrete. By showing this discrete and continuous system, I think the key idea generalizes to many engineering applications from meta-materials to complex networks, to other types of structures, and so on.

There are steps that we are thinking about immediately, and a natural question is around more complex mechanical systems and more physics, like, you start adding different forms of elastic behavior. Then, you can also think about different types of components. We are also thinking about how precision in large language models can be incorporated, and some of the learnings will transfer there. We're thinking about making these models generative. Right now, they are, in some sense, retrieving mechanisms and then optimizing from a dataset, while generative models will generate these methods. We are also exploring that end-to-end learning, where the optimization is not needed.

Nobari: There are a few places in mechanical engineering where they're used, and there's very common applications of systems for this kind of inverse kinematic synthesis, where this would be useful. A couple of those that come into mind are, for example, in car suspension systems, where you want a specific motion path for your overall suspension mechanism. Usually, they model that in 2D with planner models of the overall suspension mechanism.

I think that the next step, and what is ultimately going to be very useful, is demonstrating the same framework or a similar framework for other complicated problems that involve combinatory and continuous values.

These problems include one of the things that I've been looking into: compliant mechanisms. For example, when you have the mechanics of continual — instead of these discrete — rigid linkages, you would have a distribution of materials and motion, and one part of the material deforms the rest of the material to give you a different kind of motion.

With compliant mechanisms, there's a bunch of different places they're used, sometimes in precision machines for fixture mechanisms, where you want a specific piece that is held in place, using a mechanism that fixtures it, which can do it consistently and with very high precision. If you could automate a lot of that with this kind of framework, it would be very useful. These are all difficult problems that involve both combinatorial design variables and continuous design variables. I think that we are very close to that, and ultimately that will be the final stage.

This work was supported, in part, by the MIT-IBM Watson AI Lab.

'It might pave the way for novel forms of artistic expression': Generative AI isn't a threat to artists — it's an opportunity to redefine art itself

One of the key areas that artificial intelligence (AI) threatens to disrupt is human creativity — and the rise of generative AI has certainly thrown art into the spotlight. While fears remain that AI may replace human input and agency across society, a different approach suggests humans will meld with AI in some capacity — with the new technologies augmenting us rather than undermining us.

In "Centaur Art: The Future of Art in the Age of Generative AI" (Springer, 2024), computer scientist Remo Pareschi explores the notion of "centauric intelligence" — an integration of human and computing intelligence — and its impact on the future of art. In this excerpt, Pareschi explains how our primal fears are misguided and argues that the rise of AI may, in fact, help human creative endeavors transcend to new heights.

As we revisit our initial, most pressing concern — will artificial intelligence surpass human creativity in artistic endeavors? — it's crucial to recognize that the question, as commonly posed, is somewhat misdirected. Unlike games such as chess or Go, art cannot be measured by a simple win-lose metric. The fear, however, is similar: could humans be supplanted in artistic production as they have been in high-level chess?

Our analysis, grounded in cognitive considerations and carried out in the pages to come, suggests a nuanced answer. At the pinnacle of creativity — where inspiration, conception and originality reign — AI is an enhancer, aiding in realizing powerful and original works. In such contexts, the human artist's role remains paramount, with AI serving as a tool to augment their creative vision. Conversely, AI's role can become more structured or repetitive. It can automate the production of routine outputs such as certain types of commercial illustrations, brochures, or video game characters. This automation significantly impacts professionals in these fields, who may rely on such work for their livelihood. Consequently, these individuals may view the advent of AI technologies with apprehension and concern.

Economic and legal implications

The economic threat of generative platforms is closely intertwined with concerns about copyright infringement. A notable legal action in this arena occurred in January 2023, when a group of artists filed a class-action lawsuit against Stability AI, Midjourney, and DeviantArt. The lawsuit centered on the alleged unauthorized use of artists' works to train AI tools, sparking a debate over the legal and ethical boundaries of AI in art.

The highlighted lawsuit underscores the ongoing tension between AI’s innovative potential in art and individual artists’ rights. Plaintiffs in the case argued that AI tools were creating derivative works based on their styles without proper authorization or compensation. In contrast, the AI art companies defended their actions, asserting that the AI-generated images were transformative and original, thus not violating any laws. In a significant development in October 2023, a US judge dismissed most of these claims due to a lack of direct infringement evidence.

On the other hand, to complicate matters further, the US Copyright Office in September 2023 rejected copyright protection for *Theatre D'opera Spatial*, an artwork predominantly created by AI and crafted by artist Jason Allen. This artwork had previously won an art contest, but the Copyright Office's decision was based on the lack of significant human intervention in its creation. This stance contrasts with the position of Lawrence Lessig, a Harvard Law School professor and a renowned expert on Internet and law issues. Lessig advocates for the recognition of copyright in prompt-generated artworks, arguing that they are original and creative, embodying the human input of the prompter. He believes these works should be treated on par with other technologically aided art forms and that they have the potential to invigorate the art world by inspiring current artists and drawing in new audiences interested in AI's artistic capabilities.

Interestingly, international perspectives on this issue vary. In November 2023, a Chinese court ruled that AI-generated content could be protected under copyright law, which starkly contrasts with the human authorship requirement under U.S. copyright law.

Thus, despite these legal battles, the issue of copyright infringement in AI art remains unresolved, with the potential for future challenges and changes in various jurisdictions. This uncertainty underscores the evolving nature of art in the digital age and the need for a balanced approach that respects both innovation and artists’ rights.

A striking example of the social impact of generative platforms is the publication of *Sunyata* by Eris Edizioni, an Italian graphic novel authored by philosopher and digital artist Francesco D'Isla that combines AI-generated images with traditional text. The novel ignited controversy among artists and comic book creators, who criticized its use of AI as undermining artistic integrity and economic fairness. The author and publisher defended their work as a legitimate artistic endeavor, emphasizing their careful use of prompts and adherence to a Creative Commons license.

This case exemplifies the broader debate surrounding AI in art: balancing technological innovation with ethical considerations and the economic interests of human artists. As generative platforms continue to evolve, these discussions will likely intensify, shaping the future of art in the digital era. And yet, we might say that this is nothing new, with history repeating itself — the intersection of technology and art has always been a crucible of innovation and controversy. Exploring new artistic avenues

Indeed, throughout history, technological advancements, from ink and paper to the development of cameras and computers, have continually opened new avenues for artistic expression. Yet, each technological leap has also brought ethical and social challenges, echoing today’s tensions between generativity and control, authenticity and originality, and the impact of digital platforms on the art market.

Historically, resistance to new art forms and technologies is not a novel phenomenon but a recurring pattern. For instance, the advent of photography in the 19th century was initially met with skepticism by some critics and artists, who viewed it as a mechanical, uncreative process threatening traditional art forms. Similarly, introducing sound and color in cinema faced opposition, with concerns about diminishing the artistic value of silent and black-and-white films. Just as photography and color cinema once disrupted artistic norms, today’s generative platforms like DALL-E, Stable Diffusion, and MidJourney are provoking similar debates in the art world.

To navigate this complex landscape, the insights of Walter Benjamin and John Maynard Keynes offer valuable perspectives. Benjamin was concerned about losing aura due to the mechanical reproduction of the work of art, but also recognized its democratizing potential. Generative platforms like DALL-E, Stable Diffusion, and MidJourney take this democratization one step further, making artistic creation more accessible and fostering a sense of community and creativity. Allowing users to generate and share art potentially fulfills Benjamin's social role in art.

While Benjamin's insights shed light on the cultural implications of technological advancements in art, John Maynard Keynes's concept of technological unemployment offers a crucial economic perspective. Among his many contributions to economic theory, Keynes, a prominent economist of the 20th century, explored the job loss caused by technological advancements, a form of structural unemployment that he viewed as a ‘temporary phase of maladjustment'. This perspective is particularly relevant when considering the fears among artists about AI-powered generative platforms. While some artists worry about the potential for AI to diminish the demand for human-made art, thus impacting their livelihoods, it's crucial to recognize that technological changes can also create new job opportunities and artistic avenues.

Keynes' insights remind us that, despite initial disruptions, technological advancements often lead to the emergence of new roles and industries. In the context of art, generative AI might challenge traditional practices and pave the way for novel forms of artistic expression and collaboration.

Generative AI is transforming the landscape of numerous industries, and the creative fields are no exception. As the figurative arts become a focal point in the ongoing debate, this book explores hybrid and centauric intelligence — an integration of human and artificial intelligence.

Neuroscience sheds light on brain mechanisms underlying exceptional creativity

A new study sheds light on how highly creative individuals, such as visual artists and scientists, may have brains that function differently compared to others. The research, published in *Psychology of Aesthetics, Creativity, and the Arts*, reveals that people who exhibit exceptional creativity—referred to as "Big C" creative individuals—demonstrate more random patterns of connectivity in their brains. By using functional MRI (fMRI) technology, the researchers observed that highly creative brains bypass typical neural hubs, making distant connections between different regions of the brain more quickly and efficiently.

The purpose of the study was to explore the biological foundations of exceptional creativity. Despite over seventy years of research on creative achievement, there has been limited data to support the biological mechanisms that differentiate highly creative individuals from others. Most studies of brain function in creativity have focused on everyday or professional-level creativity.

However, few have investigated what happens in the brains of those who make transformative, world-changing contributions in the arts and sciences—people often referred to as "Big C" creative types. These individuals are not only distinguished by their high levels of creative achievement but also by their ability to think in novel and non-linear ways.

The new study sought to fill the gap in understanding how the brains of these exceptional individuals work differently from both typical people and those who are merely highly intelligent. The researchers were specifically interested in how brain regions responsible for creativity, problem-solving, and artistic or scientific invention interact during tasks that demand creative thinking.

“I became interested in the topic of creativity because creativity is elusive,” said study author Ariana Anderson, an assistant research professor at the Semel Institute for Neuroscience and Human Behavior at UCLA. “People can be highly creative without being highly educated, yet most studies of creativity have compared highly intelligent and creative individuals with ‘garden variety’ average people.”

“This confound suggests that the studies might be identifying what makes some individuals more clever than others, but not necessarily more creative. Our study compared creative people, who tend to be smarter than average, with garden variety smart people with equal intelligence.”

To investigate the neural basis of exceptional creativity, the research team recruited highly creative visual artists and scientists, as well as a comparison group of individuals matched for intelligence but not necessarily known for creative accomplishments. The study’s sample consisted of 66 participants: 21 Big C visual artists, 21 Big C scientists, and 24 “smart” individuals from the general population who served as a control group.

Each participant underwent brain scanning using fMRI technology, which measures brain activity by detecting changes in blood flow. The researchers captured brain connectivity both while participants were at rest and while they completed tasks designed to test their creative thinking. These tasks included:

・**The Alternative Uses Test**, which required participants to think of as many different uses as possible for a common object (for example, an umbrella).

・**The Remote Associates Test**, which presented three seemingly unrelated words and asked participants to find a fourth word that connected them (for example, the word “horse” connects the words “sea,” “rocking,” and “shoe”).

The researchers used a mathematical approach called graph theory to analyze the brain’s connectivity patterns. In this context, the brain’s regions were treated as “nodes,” and the connections between them as “edges.” The goal was to see how efficiently information flowed through these networks and whether Big C individuals exhibited distinct connectivity patterns compared to the control group.

During the resting-state scans, when participants were not engaged in any specific task, the Big C individuals showed more random patterns of brain connectivity compared to the control group. Specifically, they exhibited less “small-worldness”, a feature of brain networks that indicates an efficient balance between local and global connections. Instead of maintaining a highly organized structure, their brains displayed less clustering of connections between nearby regions, with more randomness overall.

However, locally, the creative individuals had increased clustering and efficiency, meaning certain brain areas were more specialized or active at rest. This suggests that while their overall brain network was more random, specific regions were more densely connected, potentially preparing them for creative thinking.

During the Alternative Uses Test, the Big C individuals had lower local efficiency and clustering compared to the control group. In other words, their brain activity was less organized and efficient while performing the task, which aligns with the idea that their brains may function in a more exploratory and less constrained manner during creative tasks. This reduced local connectivity suggests that, instead of focusing on specific brain regions, the creative individuals' brains may adopt a more flexible approach, allowing for the generation of diverse and novel ideas.

"Our study found that creative individuals exhibited more random connectivity in their brains," Anderson told PsyPost. "This suggests that to be creative, we need to focus less and relax more. However, relaxing doesn't mean watching TikTok—it means resting our brains so they can generate their own internal content, rather than being influenced by external sources. In fact, our study showed the greatest differences in brain activity when creative individuals were doing nothing—not when they were actively trying to be creative or clever. Mind-wandering can be the optimal time for our creative brains to shine."

Interestingly, no significant differences in brain connectivity were found during the Remote Associates Test. The lack of differences during this task suggests that while the Big C individuals excel in making broad, random connections during divergent thinking, their brain connectivity during tasks that require finding one correct solution may be similar to that of non-creative individuals.

"The creative group did not show significant differences in verbal word-play tasks compared to the IQ-matched group," Anderson explained. "For example, if given the words 'house, horse, dragon,' both a creative and non-creative person would display similar brain activity when identifying the common word that links them ('fly')."

Despite these intriguing findings, the study has some limitations. One challenge in studying exceptional creativity is that it is difficult to recruit large samples of individuals who have achieved such high levels of success in their fields. As a result, the sample size in this study was relatively small, which limits the ability to detect more subtle differences between groups.

"Major caveats of our study include that we compared individuals already well-known for their creativity," Anderson noted. "It doesn't address the question of what makes some people highly creative, nor whether creativity is an inherent trait, or something that can be acquired *or* diminished. Many studies have shown that creativity rapidly diminishes in early childhood, so it's crucial to explore how cultural shifts in parenting and screen time may be stifling the creative potential of children."

"My long-term goals for this research are to determine how we can foster creativity in children. Do we become more creative through exposure to the arts or nature, or do we merely learn to mimic others' styles, thus limiting originality? How does screen time affect children's ability to generate new ideas, given that they are constantly exposed to repetitive content?"

"A 2019 study showed that today's children are much less creative than previous generations of children," Anderson added.

"With post-COVID education being highly dependent on screens, it's likely this trend is worsening. This will inevitably result in decreased innovation from future generations, which could have economic consequences."

The study, "Big-C Creativity in Artists and Scientists is Associated With More Random Global but Less Random Local fMRI Functional Connectivity," was authored by Ariana Anderson, Kevin Japardi, Kendra S. Knudsen, Susan Y. Bookheimer, Dara G. Ghahremani, and Robert M. Bilder

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Genres like fantasy and science fiction are complementary, according to MIT Senior Madison Wang, a double major in creative writing and chemistry. "Constructing an effective world means ensuring readers understand characters' motivations — the 'why' — and ensuring it makes sense," she says. "It's also important to show how actions and their consequences influence and motivate characters."

Neuroscience sheds light on brain mechanisms underlying exceptional creativity

A new study sheds light on how highly creative individuals, such as visual artists and scientists, may have brains that function differently compared to others. The research, published in *Psychology of Aesthetics, Creativity, and the Arts*, reveals that people who exhibit exceptional creativity—referred to as "Big C" creative individuals—demonstrate more random patterns of connectivity in their brains. By using functional MRI (fMRI) technology, the researchers observed that highly creative brains bypass typical neural hubs, making distant connections between different regions of the brain more quickly and efficiently.

The purpose of the study was to explore the biological foundations of exceptional creativity. Despite over seventy years of research on creative achievement, there has been limited data to support the biological mechanisms that differentiate highly creative individuals from others. Most studies of brain function in creativity have focused on everyday or professional-level creativity.

However, few have investigated what happens in the brains of those who make transformative, world-changing contributions in the arts and sciences—people often referred to as "Big C" creative types. These individuals are not only distinguished by their high levels of creative achievement but also by their ability to think in novel and non-linear ways.

The new study sought to fill the gap in understanding how the brains of these exceptional individuals work differently from both typical people and those who are merely highly intelligent. The researchers were specifically interested in how brain regions responsible for creativity, problem-solving, and artistic or scientific invention interact during tasks that demand creative thinking.

"I became interested in the topic of creativity because creativity is elusive," said study author Ariana Anderson, an assistant research professor at the Semel Institute for Neuroscience and Human Behavior at UCLA. "People can be highly creative without being highly educated, yet most studies of creativity have compared highly intelligent and creative individuals with 'garden variety' average people."

"This confound suggests that the studies might be identifying what makes some individuals more clever than others, but not necessarily more creative. Our study compared creative people, who tend to be smarter than average, with garden variety smart people with equal intelligence."

To investigate the neural basis of exceptional creativity, the research team recruited highly creative visual artists and scientists, as well as a comparison group of individuals matched for intelligence but not necessarily known for creative accomplishments. The study's sample consisted of 66 participants: 21 Big C visual artists, 21 Big C scientists, and 24 "smart" individuals from the general population who served as a control group.

Each participant underwent brain scanning using fMRI technology, which measures brain activity by detecting changes in blood flow. The researchers captured brain connectivity both while participants were at rest and while they completed tasks designed to test their creative thinking. These tasks included:

・**The Alternative Uses Test**, which required participants to think of as many different uses as possible for a common object (for example, an umbrella).

・**The Remote Associates Test**, which presented three seemingly unrelated words and asked participants to find a fourth word that connected them (for example, the word "horse" connects the words "sea," "rocking," and "shoe").

The researchers used a mathematical approach called graph theory to analyze the brain's connectivity patterns. In this context, the brain's regions were treated as "nodes," and the connections between them as "edges." The goal was to see how efficiently information flowed through these networks and whether Big C individuals exhibited distinct connectivity patterns compared to the control group.

During the resting-state scans, when participants were not engaged in any specific task, the Big C individuals showed more random patterns of brain connectivity compared to the control group. Specifically, they exhibited less "small-worldness", a feature of brain networks that indicates an efficient balance between local and global connections. Instead of maintaining a highly organized structure, their brains displayed less clustering of connections between nearby regions, with more randomness overall.

However, locally, the creative individuals had increased clustering and efficiency, meaning certain brain areas were more specialized or active at rest. This suggests that while their overall brain network was more random, specific regions were more densely connected, potentially preparing them for creative thinking.

During the Alternative Uses Test, the Big C individuals had lower local efficiency and clustering compared to the control group. In other words, their brain activity was less organized and efficient while performing the task, which aligns with the idea that their brains may function in a more exploratory and less constrained manner during creative tasks. This reduced local connectivity suggests that, instead of focusing on specific brain regions, the creative individuals' brains may adopt a more flexible approach, allowing for the generation of diverse and novel ideas.

"Our study found that creative individuals exhibited more random connectivity in their brains," Anderson told PsyPost. "This suggests that to be creative, we need to focus less and relax more. However, relaxing doesn't mean watching TikTok—it means resting our brains so they can generate their own internal content, rather than being influenced by external sources. In fact, our study showed the greatest differences in brain activity when creative individuals were doing nothing—not when they were actively trying to be creative or clever. Mind-wandering can be the optimal time for our creative brains to shine."

Interestingly, no significant differences in brain connectivity were found during the Remote Associates Test. The lack of differences during this task suggests that while the Big C individuals excel in making broad, random connections during divergent thinking, their brain connectivity during tasks that require finding one correct solution may be similar to that of non-creative individuals.

“The creative group did not show significant differences in verbal word-play tasks compared to the IQ-matched group,” Anderson explained. “For example, if given the words ‘house, horse, dragon,’ both a creative and non-creative person would display similar brain activity when identifying the common word that links them (‘fly’).”

Despite these intriguing findings, the study has some limitations. One challenge in studying exceptional creativity is that it is difficult to recruit large samples of individuals who have achieved such high levels of success in their fields. As a result, the sample size in this study was relatively small, which limits the ability to detect more subtle differences between groups.

“Major caveats of our study include that we compared individuals already well-known for their creativity,” Anderson noted. “It doesn’t address the question of what makes some people highly creative, nor whether creativity is an inherent trait, or something that can be acquired *or* diminished. Many studies have shown that creativity rapidly diminishes in early childhood, so it’s crucial to explore how cultural shifts in parenting and screen time may be stifling the creative potential of children.”

“My long-term goals for this research are to determine how we can foster creativity in children. Do we become more creative through exposure to the arts or nature, or do we merely learn to mimic others' styles, thus limiting originality? How does screen time affect children's ability to generate new ideas, given that they are constantly exposed to repetitive content?"

"A 2019 study showed that today's children are much less creative than previous generations of children," Anderson added. "With post-COVID education being highly dependent on screens, it's likely this trend is worsening. This will inevitably result in decreased innovation from future generations, which could have economic consequences."

The study, "Big-C Creativity in Artists and Scientists is Associated With More Random Global but Less Random Local fMRI Functional Connectivity," was authored by Ariana Anderson, Kevin Japardi, Kendra S. Knudsen, Susan Y. Bookheimer, Dara G. Ghahremani, and Robert M. Bilder.

Creativity starts in the cradle, new research shows

First steps into the world of numerosity: a baby thoughtfully observing sets of different objects. Credit: Peter Lengyel-Szabo© Provided by Medical Xpress

Infants less than 1 year old can combine simple concepts into complex ideas, showing that creativity begins in babyhood. According to new research at the University of Birmingham, in the U.K., and Central European University (CEU), in Austria, babies are not only capable of creative thinking well before starting to speak, but this sort of thinking may be essential for language acquisition.

In the study, published in the *Proceedings of the National Academy of Sciences*, the researchers set out to explore the origins of human creativity and productive thinking to try to find out how people arrive at completely new thoughts and ideas. The basic mechanism for doing this is taking familiar concepts and combining them into new structures, but little is known about how early in life these abilities can be used.

The researchers found that babies were able to very quickly learn new words that describe small quantities—an impressive achievement—and combine these spontaneously with familiar words to fully understand a phrase.

Lead researcher, Dr. Barbara Pomiechowska, carried out the research while a postdoctoral fellow at the Central European University (CEU). She is now an assistant professor in the School of Psychology, at the University of Birmingham, in the U.K.

Dr. Pomiechowska said, "Human creativity has no boundaries: It has taken us to the moon and allowed us to cure deadly diseases—but despite its importance, we don't yet know when and how this impressive ability to combine ideas and invent new things emerges. This research shows that we must go right back to the beginning of language acquisition to solve this puzzle."

In the study, the researchers worked with a cohort of 60 babies, all around the age of 12 months. They started by teaching the babies two novel words describing quantity: "mize," to mean "one," and "padu," to mean "two."

Then the babies were asked to combine these new number words with different object names, for example, to identify "padu ducks" from among a choice of images. By teaching novel words to represent quantities, the researchers were able to test the babies' ability to combine concepts in real time, rather than simply recall combinations of words that they already knew from previous experience.

By using eye-tracking technology to monitor where the babies look, the researchers were able to show that the infants could successfully combine the two concepts to understand what they were being asked about.

Dr. Agnes Kovacs, from CEU's Department of Cognitive Science and CEU's Cognitive Development Center, added, "For babies, this ability to combine different concepts is likely to help not only to interpret the complex language input, but also to learn about different aspects of the physical and social world. For adults, it's an ability that helps to move past everything that's already been thought of, opening the mind towards endless possibilities."

More information: Barbara Pomiechowska et al, Early-emerging combinatorial thought: Human infants flexibly combine kind and quantity concepts, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2315149121

Provided by University of Birmingham

What does neurotypical, neurodivergent, and neurodiverse mean?

- Neurotypical
- Neurodivergent
- Neurodiversity
- Which term is better?
- Benefits
- Summary

The word “neurotypical” describes someone who thinks and processes information in ways that are typical within their culture. They tend to learn skills and reach developmental milestones around the same time as their peers.

In contrast, the term “neurodivergent” describes someone who processes information in a different way. Autistic people and those with attention deficit hyperactivity disorder (ADHD) and similar conditions sometimes identify as neurodivergent.

These words can be a way of moving discussions away from focusing on a disease or mental health disorder, implying instead that people simply have a different way of understanding and interacting with the world.

However, some argue that the term “neurodiversity” is better still. This word refers to various ways that individuals think and behave. Rather than frame one way as typical and the other as atypical, “neurodiversity” embraces a continuum of possibilities.

In this article, we will look at what it means to be neurotypical and neurodivergent and explore some traits that share associations with these words. We will also look at neurodiversity and its benefits.

What does neurotypical mean?

The term neurotypical describes someone who thinks and processes information in an expected way for their culture and setting.

Some characteristics that people associate with neurotypical development include:

- reaching developmental milestones at a similar time to other children, such as learning to speak
- having social or organizational skills that are similar to someone’s peers
- being able to tolerate some sensory discomfort, such as loud noises, without much difficulty
- being able to adapt to changes in routines
- being able to focus in class or at work for prolonged periods
- having varied interests or hobbies typical for the person’s age

A neurotypical person does not necessarily have all of these traits or have them in all situations to identify as neurotypical.

For example, some people without autism may feel overwhelmed by certain sensory experiences, such as being in a crowd. Some children also have delays in learning speech or other skills that are not a result of any diagnosis.

The meaning “neurotypical” is also subjective, to an extent. What people consider typical can vary according to context.

For example, a 2018 studyTrusted Source comparing data from the United States, India, and Japan looked at the characteristics doctors use to distinguish autistic from allistic — or nonautistic — people. Researchers found that while many traits were consistent across groups, others depended on the culture.

What does neurodivergent mean?

The term “neurodivergent” describes people who process information and behave in a way that differs from the actual or perceived norms of a particular culture. It is a way to discuss diagnoses, such as autism, in a way that does not frame it as a problem or an illness.

According to the United Kingdom charity ADHD Aware, 30–40% of the population are neurodivergent. As with the term “neurotypical,” though, the term has no fixed meaning.

Neurodivergence comes in many forms. People with the following may consider themselves neurodivergent:

- **ADHD:** People with ADHD oftenTrusted Source have high levels of energy, which may cause hyperactivity and difficulty sitting still at school or work. Therefore, staying focused or organized can also be difficult. However, these traits can also mean people with ADHD are spontaneous and dynamic.
- **Learning disabilities:** Learning disabilities affect how someone learns or takes in information. For example, dyslexia affects a person's ability to read, while dysgraphia affects handwriting and fine motor skills. People with these diagnoses are not unintelligent or incapable of learning — in fact, they often have average or above-average intelligence. However, they can benefit from learning in different ways.
- **Autism:** Autism affects how someone processes sensory information and how they think and communicate. For example, an autistic individual may be very sensitive to certain sounds and noises or have trouble reading social cues. Others may have very specific, in-depth interests. The effects vary greatly from person to person.
- **Tourette's syndrome:** People with Tourette's syndrome have a neurological condition that causes them to make involuntary movements or sounds, known as tics.
- **Synesthesia:** Individuals with synesthesia experience the senses in different ways. They may see colors or shapes when they hear music or taste certain flavors when they hear words. They may only experience this in their "mind's eye," or externally in the world around them.

Some consider rare forms of giftedness to be part of neurodivergence too. For example, people with hyperthymesia have a highly accurate memory of their own life experiences.

Does neurodivergence include mental health?

The above diagnoses are not mental health conditions — they are neurodevelopmental in origin. They come with long term traits that do not change over time.

However, some people consider mental health conditions to be part of neurodivergence because they can also change how someone thinks and behaves. People with these conditions can also face some of the same challenges, such as feeling misunderstood or experiencing stigma.

However, mental health conditions have some characteristics that make them distinct:

- **Quality of life:** Being neurodivergent does not necessarily reduce quality of life. In the right circumstances, people who identify as such can lead fulfilling lives. However, a supportive environment does not prevent mental health conditions from affecting quality of life.
- **Identity:** For many, neurodiversity is part of their identity. Some may also feel this way about their mental health condition. In some situations, this viewpoint could cause harm. For example, seeing anorexia as a lifestyle or identity can mean people do not seek treatment, which could be fatal.
- **Treatment:** Finally, many mental health conditions are treatable and can improve significantly with support and therapy. The same is not true for autism, learning disabilities, and other types of neurodivergence. Though there is no cure

for these diagnoses, appropriate support can help people learn the skills they find challenging.

ADHD Aware states that eventually, some long term conditions that people consider psychological, such as schizophrenia or antisocial personality disorder, may ultimately become part of the concept of neurodivergence or neurodiversity.

The more scientists discover how these conditions work, the more the language will evolve.

What is neurodiversity?

Neurodiversity refers to the wide spectrum of ways that people think. It frames differences in cognition as variations, all of which are equally normal and valuable.

The concept became popular in the 1990s, when sociologist Judy Singer proposed that autism arises from the brain working differently from nonautistic individuals. She also highlighted that this is not a fault but a difference. Neurodiversity has since become a movement, changing how people see autism and other diagnoses.

Neurodiversity advocates may still use the terms “neurotypical” and “neurodivergent” to identify where they are on the neurodiversity spectrum or talk about others. However, everyone is included in neurodiversity, regardless of how their brain functions.

Which terms are better?

There are mixed opinions on whether the terms “neurotypical” and “neurodivergent” are helpful.

Some feel that “neurotypical” is an accurate reflection of how many people understand the world and social interactions in a similar or typical way.

The word can also reflect the privileges from which neurotypical people can benefit. Because their peers consider them “typical,” people who fall into this category often have an easier time in school, the workplace, and relationships.

However, others say that calling one group “typical” reinforces the idea that while some people think typically, others think atypically. A 2021 paper argues that this is both scientifically inaccurate and harmful.

The authors say that diversity in how people think is a natural product of evolution and that it is natural for human brains and bodies to vary. To consider one type of cognition “typical” ignores this fact.

How a person identifies and describes themselves is ultimately a personal choice. Generally, it is a good idea to use the terms an individual prefers.

What are the benefits of neurodiversity?

Supporters for neurodiversity believe that variations in thinking are beneficial to society, adding different perspectives and ideas. Teaching children about neurodiversity may:

- reduce fear about the way their brain works or how they differ from others
- encourage them to see differences as normal and natural
- teach them about being aware of harmless behaviors, such as stimming
- help cultivate healthy self-esteem
- empower children to advocate for their needs, for example, if they are have reading difficulties in class
- feel confident about their unique abilities

On a personal level, the benefits for adults are very similar. Learning about neurodiversity can change how people see themselves or those around them.

On a broader scale, acceptance of neurodiversity may:

- help parents and caregivers understand and care for their children
- help teachers understand how best to educate children with a range of needs
- encourage employers to hire neurodiverse people, reducing unemployment
- increase positive representations of neurodiversity in the media

- decrease stigma, bullying, and discrimination

Summary

The word “neurotypical” refers to people who have brains that function in a similar way to most of their peers. Individuals who are neurotypical develop skills, such as social or organizational skills, at around the same rate as others their age. They can also tolerate change, disruption in routines, and distractions without too much difficulty.

In contrast, people who consider themselves neurodivergent have brains that function differently. They may have a diagnosis such as ASD, ADHD, dyslexia, or Tourette’s syndrome. Neurodivergence comes in many forms, and they affect people with these diagnoses differently.

'Noisy' autistic brains seem better at certain tasks. Here's why neuroaffirmative research matters

Autism is a neurodevelopmental difference associated with specific experiences and characteristics.

For decades, autism research has focused on behavioral, cognitive, social and communication difficulties. These studies highlighted how autistic people face issues with everyday tasks that allistic (meaning non-autistic) people do not. Some difficulties may include recognizing emotions or social cues.

But some research, including our own study, has explored specific advantages in autism. Studies have shown that in some cognitive tasks, autistic people perform better than allistic people. Autistic people may have greater success in identifying a simple shape embedded within a more complex design, arranging blocks of different shapes and colors, or spotting an object within a cluttered visual environment (similar to Where's Wally?). Such enhanced performance has been recorded in babies as young as nine months who show emerging signs of autism.

How and why do autistic individuals do so well on these tasks? The answer may be surprising: more "neural noise."

What is neural noise?

Generally, when you think of noise, you probably think of auditory noise, the ups and downs in the amplitude of sound frequencies we hear.

A similar thing happens in the brain with random fluctuations in neural activity. This is called neural noise.

This noise is always present, and comes on top of any brain activity caused by things we see, hear, smell and touch. This means that in the brain, an identical stimulus that is presented multiple times won't cause exactly the same activity. Sometimes the brain is more active, sometimes less. In fact, even the response to a single stimulus or event will fluctuate continuously.

Neural noise in autism

There are many sources of neural noise in the brain. These include how the neurons become excited and calm again, changes in attention and arousal levels, and biochemical processes at the cellular level, among others. An allistic brain has mechanisms to manage and use this noise. For instance, cells in the hippocampus (the brain's memory system) can make use of neural noise to enhance memory encoding and recall.

Evidence for high neural noise in autism can be seen in electroencephalography (EEG) recordings, where increased levels of neural fluctuations were observed in autistic children. This means their neural activity is less predictable, showing a wider range of activity (higher ups and downs) in response to the same stimulus.

In simple terms, if we imagine the EEG responses like a sound wave, we would expect to see small ups and downs (amplitude) in allistic brains each time they encounter a stimulus. But autistic brains seem to show bigger ups and downs, demonstrating greater amplitude of neural noise.

Many studies have linked this noisy autistic brain with cognitive, social and behavioral difficulties.

But could noise be a bonus?

The diagnosis of autism has a long clinical history. A shift from the medical to a more social model has also seen advocacy for it to be reframed as a difference, rather than a disorder or deficit. This change has also entered autism research. Neuroaffirming research can examine the uniqueness and strengths of neurodivergence.

Psychology and perception researcher David Simmons and colleagues at the University of Glasgow were the first to suggest that while high neural noise is generally a disadvantage in autism, it can sometimes provide benefits due to a phenomenon called stochastic resonance. This is where optimal amounts of noise can enhance performance. In line with this theory, high neural noise in the autistic brain might enhance performance for some cognitive tasks.

Our 2023 research explores this idea. We recruited participants from the general population and investigated their performance on letter-detection tasks. At the same time, we measured their level of autistic traits.

We performed two letter-detection experiments (one in a lab and one online) where participants had to identify a letter when displayed among background visual static of various intensities.

By using the static, we added additional visual noise to the neural noise already present in our participants' brains. We hypothesized the visual noise would push participants with low internal brain noise (or low autistic traits) to perform better (as suggested by previous research on stochastic resonance). The more interesting prediction was that noise would not help individuals who already had a lot of brain noise (that is, those with high autistic traits), because their own neural noise already ensured optimal performance.

Indeed, one of our experiments showed people with high neural noise (high autistic traits) did not benefit from additional noise. Moreover, they showed superior performance (greater accuracy) relative to people with low neural noise when the added visual static was low. This suggests their own neural noise already caused a natural stochastic resonance effect, resulting in better performance.

It is important to note we did not include clinically diagnosed autistic participants, but overall, we showed the theory of enhanced performance due to stochastic resonance in autism has merits.

Why this is important?

Autistic people face ignorance, prejudice and discrimination that can harm well-being. Poor mental and physical health, reduced social connections and increased "camouflaging" of autistic traits are some of the negative impacts that autistic people face.

So, research underlining and investigating the strengths inherent in autism can help reduce stigma, allow autistic people to be themselves and acknowledge autistic people do not require "fixing."

The autistic brain is different. It comes with limitations, but it also has its strengths.

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1. Head Center: Gateway to Inspiration

Located at the top of the body graph, the Head Center serves as the gateway for inspiration and ideas. This center is associated with mental pressure and the constant stream of thoughts and possibilities.

If you have a strong ability to think, you may often come up with ideas and feel pressure to understand them.

You might absorb mental pressure from your environment if you don't have a clear Head Center. This can lead to overthinking and feeling overwhelmed by the influx of ideas.

Knowing whether your Head Center is defined or undefined can help you understand how you make decisions.

2. Ajna Center: Shaping Thoughts and Ideas

The Ajna Center, located between the eyebrows, is where thoughts and ideas shape. It is associated with mental understanding, conceptualization, and the formation of beliefs.

If you have a defined Ajna Center, it means you process information consistently and reliably.

On the other hand, if your Ajna Center is undefined, you might tend to take in and amplify the thoughts of others.

To understand how you solve problems and make decisions, look at your Ajna Center. Recognizing the dynamics of your Ajna Center can empower you to make decisions aligned with your authentic self.

3. Throat Center: Expressing Your Truth

As we move down the body graph, we reach the Throat Center. This energy center is important for talking and expressing ourselves. If your Throat Center is defined, you have a consistent way of expressing yourself.

But if it's undefined, you might adopt others' communication styles.

No matter how well you communicate, your Throat Center affects how you express your truth. Improving your Throat Center can make you a better communicator and show your true self.

4. G Center: The Seat of Identity and Love

At the center of the body graph lies the G Center, often referred to as the "diamond" or "heart" center. This energy center is associated with identity, direction in life, and the experience of love.

If you have a defined G Center, you know who you are and feel love easily. But if your G Center is undefined, you might look for your identity and love from others.

Exploring your G Center can give you deep insights into your purpose and relationships. By understanding your G Center, you can live a more authentic and love-filled life.

5. Will Center: Harnessing Personal Power

Moving further down, we encounter the Will Center, also known as the Ego Center. This energy center is associated with willpower, drive, and self-worth.

If you have a defined Will Center, you have a strong source of personal power. But if your Will Center is undefined, you might feel unworthy and seek validation from others.

When you understand your Will Center, you can feel empowered to achieve your goals confidently. Understanding your Will Center can help you feel more confident and empowered in life.

6. Spleen Center: Intuition and Survival Instincts

The Spleen Center is on the right side of the body. It is linked to intuition, survival instincts, and the immune system. If your Spleen Center is defined, it means you have reliable intuition and strong survival instincts.

If it's undefined, you might absorb the fears and anxieties of others.

You can improve your well-being by listening to the signals from your Spleen Center. By understanding how your Spleen Center works, you can make better decisions for your health.

7. Solar Plexus Center: Navigating Emotions

The Solar Plexus Center is in the emotional solar plexus region and is linked to feelings, moods, and energy changes. If you have a defined Solar Plexus Center, it means you always feel the same emotionally.

But if your Solar Plexus is undefined, you might absorb other people's emotions.

You can gain insights into your emotions by understanding your Solar Plexus Center. Exploring the dynamics of your Solar Plexus Center can lead to a more balanced and authentic experience of your emotional life.

8. Sacral Center: The Engine of Life

The Sacral Center, often called the "generator," is a powerful energy center associated with life force, vitality, and work. A defined Sacral Center indicates a consistent and reliable source of energy.

Additionally, a person with an open Sacral center becomes the best at Projector Human Design reading. By understanding your Sacral Center, you can change how you approach work, relationships, and life, leading to personal growth.

Do you know what you truly want and how much energy you have? Or do you force yourself to keep going even when you're tired just to meet others' demands?

Exploring the dynamics of your Sacral Center can lead to a more energized and fulfilling way of living.

9. Root Center: Dealing with Pressure

Finally, the final of the nine human design centers is the Root Center, located at the base of the spine. This energy center is associated with pressure, stress, and the body's response to time.

If you have a defined Root Center, you can handle pressure and time-related challenges well. But if your Root is undefined, you may feel pressured and adopt the pace of others.

Understanding your Root Center can change how you handle stress and pressure from time to time. Exploring the dynamics of your Root Center can empower you to navigate

life's challenges with resilience and a sense of self-discovery.

Embracing the Wholeness of Human Design Centers

To sum up, knowing the nine human design centers is essential. This helps us embrace our unique energy and make decisions that match who we are.

Each center holds valuable insights and guidance from the head to the root for living a fulfilling and authentic life.

Take the first step towards self-discovery and explore your design with a professional human design reading. Your journey toward self-awareness and personal growth awaits. Book your session today.

If you enjoyed this article and would like to read more like it, then check out the rest of our website.

The post Understanding The 9 Human Design Centers: From The Head To The Root appeared first on Kellys Thoughts On Things.

Your True Potential: How Human Design Centers Can Help You Thrive© Provided by New York Tech

In the unique cosmos of human design, the centers hold a significant role. They act as guiding stars to self-realization and personal growth.

These centers echo the profound wisdom that lies within. Understanding them can unlock potentials you never knew existed.

Welcome to our exploration of how the Human Design Centers can help you thrive. In this journey, we will delve into the profound essence of these centers. We'll also uncover their power to shape your lives and drive you toward a thriving existence.

Unveiling Your Authentic Self: The Quest for Self-Discovery

In your journey for self-discovery, the key lies in realizing and embracing our authentic selves. This quest goes beyond the surface level of your conscious identities to the deep, intricate designs that make you unique.

The Human Design Centers serve as a roadmap in this exploration, leading you to the richness of your individuality. They shed light on your inherent strengths, shadows, gifts, and tendencies. This provides you with insight to align with your true potential.

By understanding their role and embracing their wisdom, you can step into your authenticity. This empowers me to thrive in all aspects of life.

Empowered Decision-Making: The Influence of Human Design

This is one of the significant strengths of the Human Design Center. These centers harness the energies that guide your choices, shaping the way you respond or react to life's circumstances.

They provide you with an inner compass, pointing you toward decisions that resonate with your true self. As you align more with these centers, you find yourselves making decisions that not only reflect your authenticity.

Harmonizing Connections: Transformative Relationships Through Design

In your quest for connections and relationships, Human Design Centers play a transformative role. They help you understand not just yourself but also how you connect with others, shaping the dynamics of your relationships.

By decoding the energies and patterns inherent in your design, you learn how to harmonize your interactions. It also allows you to foster connections that are enriching and fulfilling. As you align with your design, you enable yourself to engage in relationships. These reflect your authenticity and promote mutual growth.

Well-Being Alchemy: Human Design Centers and the Pursuit of Balance

In the realm of human design, the pursuit of balance is quintessential, and the Human Design Centers play a vital role in this quest. These centers serve as a guide. It helps understand your own energy flows. This guides you to effectively manage your energies and foster overall well-being.

When you comprehend these centers, you discover the keys to maintaining equilibrium in all aspects of life. Be it physical, emotional, or mental. Through this understanding, you can transform your lives into a balanced symphony of experiences. This, later on, enables you to thrive. This balance is the essence of well-being alchemy that the Human Design Centers help you achieve.

Mastering Life’s EBB and Flow: Adaptability Through Design Awareness

In your journey through life, you encounter various ebbs and flows, ups and downs, successes and setbacks. The Human Design Centers, in their profound wisdom, offer you the tools to navigate these changes with grace and resilience.

By fostering a deep awareness of your design, you equip yourself with the ability to adapt and flow with life’s varying currents. This adaptability doesn’t allow you to survive. It empowers you to thrive, finding growth and learning in every situation.

Living in Abundance: Human Design Centers and Career Alignment

Human design sacral centers offer unique insight into how you can best utilize your inherent talents and abilities. They guide you toward career paths and professional decisions that align with your true self and add value to your life.

By understanding the energies and patterns, you can identify opportunities. These resonate with your core self. This leads to greater satisfaction and abundance in your professional lives.

Igniting Creative Brilliance: Human Design Centers and Innovation

In the world of creativity and innovation, this provides an array of insights into your inherent creative potential. These centers play a pivotal role in sparking your creative brilliance. This illuminates the unique ways in which you can bring innovation to life.

By understanding the energies and patterns within these centers, you can harness your creativity. This channels it in ways that align with your authentic selves. This understanding empowers you to tap into your innovative capabilities.

Mindful Living: Integrating Human Design Into Daily Practices

The practice of mindful living provides an optimal framework. This is for integrating the wisdom of Human Design Centers into your everyday routines. You can navigate daily life with greater clarity, authenticity, and purpose. This is by aligning your actions, thoughts, and responses with the insights offered by these centers.

This mindful integration of your design into your lives enables you to function in harmony with your inherent nature. It promotes a lifestyle rooted in self-awareness. This leads to a heightened state of well-being, balance, and authenticity.

Thriving Beyond Limits: The Holistic Impact of Human Design Centers

In the grand scheme of human existence, the Projector Human Design has holistic impacts on your life, propelling you to thrive beyond your perceived limits. These centers, embedded with deep wisdom, enable you to uncover and transcend your limitations, spurring you to reach higher levels of self-awareness, fulfillment, and success.

By embracing your individual design and harnessing the power of these human design strategies, you can create and experience a life that transcends conventional boundaries and limitations. This is the extraordinary potential of the Human Design Centers-they serve as catalysts for personal transformation, empowering you to thrive beyond limits.

All About Human Design Centers

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The Origin of Intelligent Design

A brief history of the scientific theory of intelligent design

Executive Summary: Critics of the theory of intelligent design often assert that it is simply a re-packaged version of creationism, and that it began after the Supreme Court struck down the teaching of creationism in *Edwards v. Aguillard* in 1987. In reality, the idea of intelligent design reaches back to Socrates and Plato, and the term "intelligent design" as an alternative to blind evolution was used as early as 1897. More recently, discoveries in physics, astronomy, information theory, biochemistry, genetics, and related disciplines during the past several decades provided the impetus for scientists and philosophers of science to develop modern design theory. Many of the central ideas for the theory of intelligent design were already being articulated by scientists and philosophers of science by the early 1980s, well before the *Edwards v. Aguillard* decision.

Opponents of the theory often insist that intelligent design emerged as a conspiracy to circumvent the 1987 Supreme Court decision, *Edwards vs. Aguillard*.[1] There the Court struck down a Louisiana law promoting the teaching of creation science in public school science classes. The theory of intelligent design, critics insist, is merely a clever end-run around this ruling, biblical creationism in disguise.

The problem with this claim is the intelligent design predates *Edwards vs. Aguillard* by many years. Its roots stretch back to design arguments made by Socrates and Plato,[2] and even the term "intelligent design" is more than 100 years old. Oxford scholar F.C.S. Schiller employed it in an 1897 essay, writing that "it will not be possible to rule out the supposition that the process of Evolution may be guided by an intelligent design."[3] For a historical time line of the design arguments stretching back to ancient times, and use of the term "intelligent design" in the last two centuries, see the timeline page at ResearchID.org.[4]

In *By Design*, a history of the current design controversy, journalist Larry Witham traces the roots of the contemporary intelligent design movement in biology to the 1950s and ’60s, and the movement itself to the 1970s.[5] Biochemists were unraveling the secret of DNA and discovering that it was part of an elaborate information processing system that included nanotechnology of unparalleled sophistication. One of the first intellectuals to describe the significance of these discoveries was chemist and philosopher Michael Polanyi, who in 1967 argued that “machines are irreducible to physics and chemistry” and that “mechanistic structures of living beings appear to be likewise irreducible.”[6]

Biochemist Michael Behe would later develop Polanyi’s insights with his concept of irreducible complexity. And mathematician William Dembski would find Polanyi’s work so influential that he would name Baylor University’s Michael Polanyi Center after him.

Polanyi’s work also influenced the seminal 1984 book *The Mystery of Life’s Origin* by Charles Thaxton (Ph.D., Physical Chemistry, Iowa State University), Walter Bradley (Ph.D., Materials Science, University of Texas, Austin), and Roger Olsen (Ph.D., Geochemistry, Colorado School of Mines). Thaxton and his co-authors argued that matter and energy can accomplish only so much by themselves, and that some things can only “be accomplished through what Michael Polanyi has called ‘a profoundly informative intervention.’”[7]

The book was written under the auspices of the Foundation for Thought and Ethics (FTE), and as the book neared completion, Thaxton and the FTE’s president, Jon Buell, approached origin-of-life researcher Dean Kenyon, author of a leading monograph in the field, *Biochemical Predestination*, and a professor of biology at San Francisco State University. They feared that Kenyon would reject their argument. Instead, he found the book “an extraordinary new analysis of an age-old question” and volunteered to write the Foreword.

Eventually the book was placed with The Philosophical Library of New York, publisher of numerous Nobel laureates, and became the best-selling advanced college-level work on chemical evolution.[8] Sales were fueled by

favorable reviews in prestigious venues like the *Yale Journal of Biology and Medicine* as well as positive responses from leading scholars. For instance, it received kudos from Klaus Dose in his major review article on origin of life studies, “The Origin of Life: More Questions Than Answers.”
Kenyon and the three authors of the book, it turned out, shared a commitment to investigating the possibility of design in nature without bringing in religious assumptions.

“My approach has always been to look at this question from entirely within a scientific framework,” Kenyon said in a recent telephone interview.[9] “After all, I came to be a dissenter to scientific materialism by looking at the origin of life experiments, including experiments of mine. My transition was from the empirical sciences, through an analysis of the empirical data in origins science, including the paleontological evidence. I grew increasingly uncomfortable presenting conclusions to my students that weren’t backed up by the empirical data.”

Kenyon said he was attracted to *The Mystery of Life’s Origin* for the cautious and rigorous way it moved from observation to conclusions without drifting into unwarranted assertions about the identity of the first organism’s designer. A key passage from the epilogue illustrates nicely this quality of the book:
We have observational evidence in the present that intelligent investigators can (and do) build contrivances to channel energy down nonrandom chemical pathways to bring about some complex chemical synthesis, even gene building. May not the principle of uniformity then be used in a broader frame of consideration to suggest that DNA had an intelligent cause at the beginning?[10]

The language here is classic intelligent design vocabulary. We find more of the same in molecular biologist Michael Denton’s 1985 book *Evolution: A Theory in Crisis*:
The inference to design is a purely a posteriori induction based on a ruthlessly consistent application of the logic of analogy. The conclusion

may have religious implications, but it does not depend on religious presuppositions.[11]

Denton does not characterize himself as a design theorist, but the quotation goes to the heart of the difference between creationism and the theory of intelligent design. The essential difference isn't whether the writer speaks of the "creation of DNA" versus the "intelligent design of DNA." The difference is more substantive than stylistic. Creationism or Creation Science is focused on defending a particular reading of the Genesis account, usually including the creation of the earth by the Biblical God a few thousand years ago. The theory of intelligent design isn't based on religious presuppositions but simply argues that an intelligent cause is the best explanation for certain features of the natural world. Unlike the creationism on trial in *Edwards vs. Aguillard*, the theory of intelligent design does not consider the identity of the designer nor does it defend the Genesis account (or that of any other sacred text for that matter). This is why a former atheist like British philosopher Antony Flew, who rejects the Judeo-Christian God, can nevertheless embrace the intelligent design argument for the origin of life.[12]

The fact that intelligent design doesn't identify the source of design is not political calculation but precise thinking, refusing to go beyond what the scientific evidence tells us. Consider intelligent design's most famous design inference, the bacterial flagellum. Michael Behe shows that this microscopic rotary engine, like an automobile engine, needs all of its machinery in place to function at all. The best explanation for this irreducibly complex machine is intelligent design, but there's no inscription on the bushing of this little motor that identifies its maker. To discover the identity of its designer(s), one has to look beyond science.

The term "intelligent design" was used to communicate this fact. In a recent telephone interview, Charles Thaxton told how, as he explored the idea of intelligent causation in the origin of life, he would sometimes use the term "create."[13] The term has a perfectly neutral dictionary meaning, but he said he became more and more aware that the term was at once

too broad and too specific. Search Google Scholar for academic references in biology to “creation,” and one gets more than 50,000 hits, often referring merely to biological processes that bring certain structures into being. To create simply means to cause something to exist.[14]
More problematic was that fact that many of Thaxton’s listeners would project into any form of the word “create” the Biblical account of creation. Since the evidence he and other design theorists were presenting said nothing about whether the God of the Bible was the source of that design, increasingly they avoided the term.

In the same year *The Mystery of Life’s Origin* appeared, Thaxton met Stephen Meyer, a young geophysicist and future program director of Discovery Institute’s Center for Science & Culture, now the institutional home for scientists and scholars around the globe working on the theory of intelligent design. Thaxton, Meyer, and others were by that time (1984) already using terms like *creative intelligence*, *intelligent cause*, *artificer*, and *intelligent artificer* as they grappled together with questions of design detection in science.

As the academic editor for the Foundation of Thought and Ethics, Thaxton was then serving as the editor for a supplemental science textbook co-authored by Kenyon, named *Of Pandas and People: The Central Question of Biological Origins*. As it neared completion, Thaxton continued to cast around for a term that was less ponderous and, at the same time, more general, a term to describe a science open to evidence for intelligent causation and free of religious assumptions. He found it in a phrase he picked up from a NASA scientist. “That’s just what I need,” Thaxton recalls thinking. “It’s a good engineering term.... After I first saw it, it seemed to jibe. When I would go to meetings, I noticed it was a phrase that would come up from time to time. And I went back through my old copies of *Science* magazine and found the term used occasionally.” It was soon incorporated into the language of the book.
From the uses Thaxton ran across at conferences and in his back issues of *Science*, Thaxton saw that *intelligent design* was already a functioning term in science, and it was just a matter of extending the term to the

process of design detection in natural structures. “I knew from Polanyi that the laws of chemistry and physics were not responsible for the sequencing of the nucleotides,” Thaxton said, “but I didn’t know how to link that to intelligence till I read Hubert Yockey’s paper in 1981 that there is a structural identity between the nucleotide sequences in DNA and the alphabetical letter sequences in a book.”[15]

Yockey wrote, “It is important to understand that we are not reasoning by analogy. The sequence hypothesis [that the exact order of symbols records the information] applies directly to the protein and the genetic text as well as to written language and therefore the treatment is mathematically identical.”[16] Yockey is not a proponent of intelligent design, but the passage marked a turning point for Thaxton: “As soon as I made the connection that it wasn’t just analogy but the treatment of these was mathematically identical, I said, ‘Well, if the treatments are mathematically identical and I know that intelligence is responsible for the alphabetical letter sequence, then I’m on safe ground when I say that intelligence is responsible for the sequencing of the nucleotides.’”[17]

The theory of intelligent design in biology emerged, in large part, from these attempts to grapple with the biological information revolution of the ‘60s and ‘70s. In his 1985 critique of modern evolutionary theory, Michael Denton commented, “It has only been over the past twenty years with the molecular biological revolution and with the advances in cybernetic and computer technology that [philosopher David] Hume’s criticism has been finally invalidated and the analogy between organisms and machines has at last become convincing.”[18]

The theory of intelligent design is larger than *Edwards vs. Aguillard.* It’s also larger than biology— a point usually missed by journalists eager to roll the debate into the rusty boilerplate of the Scopes Monkey Trial and its Hollywood caricature, *Inherit the Wind*. The 20th century provided powerful new evidence for design not only in microbiology but also in chemistry, physics, and cosmology.

If the universe were eternal, as was conventional scientific wisdom at the beginning of the 20th century, then its origin didn't need to be explained: it had no origin. But if it had a beginning, then obviously there was some explaining to do. Who or what made it? In the 1920s, Edwin Hubble discovered that light from distant galaxies had stretched on its way to earth, suggesting that the universe is expanding. This, coupled with the discovery of the microwave background radiation in the 1960s, convinced most scientists that the universe was not eternal but rather began in the finite past.

And beginning with Fred Hoyle's discovery of the carbon-12 resonance in the early 1950s,[19] physicists began uncovering a number of ways the universal constants of physics and chemistry (gravity, the strong and weak nuclear forces, etc.) were fine tuned for complex life. Reviewing these developments in 1982, leading theoretical physicist Paul Davies described the fine-tuning of the universe as "the most compelling evidence for an element of cosmic design."[20]

Hoyle, an eminent theoretical physicist and agnostic, followed with *The Intelligent Universe* (1983), featuring chapter titles like "The Information Rich Universe" and "What is Intelligence Up To?" Hoyle, no friend of Christianity or Biblical creationism, nevertheless asserted, "A component has evidently been missing from cosmological studies. The origin of the Universe, like the solution of the Rubik cube, requires an intelligence."[21] Or as Hoyle said elsewhere, "A commonsense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as chemistry and biology, and that there are no blind forces worth speaking about in nature."[22]

Hoyle's argument, thus, extended even to the realm of biology. "We are close here to what seems to be going on in the mind of the Darwinian enthusiast, whose processes of thought seem to be conditioned by the tacit assumption that the environment is intelligent, an idea which I would in part subscribe to, but one which in Darwinian theory is quite against the rules." Hoyle wrote in the same 1983 book. "A proper understanding of evolution requires that the environment, or the variations on which it operates, or both, be intelligently controlled."[23]

By now even this brief survey has brought certain facts sharply into focus. Although its roots stretch back to Plato, the modern intelligent design movement sprang from fresh discoveries in astronomy, physics, chemistry and biology. It's older than *Edwards vs. Aguillard* and much bigger than current battles over science education.

Some opponents of intelligent design, however, aren't interested in debating the evidence. They prefer to pretend that the intellectual work of scientists like Dean Kenyon revolve around *Edwards vs. Aguillard.* The theory of intelligent design owes much to law, but the laws it concerns itself with are the laws of nature. The second half of the 20th century revealed that they are exquisitely fine- tuned for life. It also revealed that while life needs a finely tuned set of physical constants, it apparently also needs something that only intelligence can provide — information. Critics of intelligent design could do with more of it.

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INTELLIGENT DESIGN

WILLIAM DEMBSKI, PHD

When the physics of Galileo and Newton displaced the physics of Aristotle, scientists tried to explain the world by discovering its deterministic natural laws. When the quantum physics of Bohr and Heisenberg in turn displaced the physics of Galileo and Newton, scientists realized they needed to supplement their deterministic natural laws by taking into account chance processes in their explanations of our universe. Chance and necessity, to use a phrase made famous by Jacques Monod, thus set the boundaries of scientific explanation.

Today, however, chance and necessity have proven insufficient to account for all scientific phenomena. Without invoking the rightly discarded teleologies, entelechies, and vitalisms of the past, one can still see that a third mode of explanation is required, namely, intelligent design. Chance, necessity, and design — these three modes of explanation — are needed to explain the full range of scientific phenomena.

Not all scientists see that excluding intelligent design artificially restricts science, however. Richard Dawkins, an arch-Darwinist, begins his book *The Blind Watchmaker* by stating, “Biology is the study of complicated things that give the appearance of having been designed for a purpose.”

Statements like this echo throughout the biological literature. In *What Mad Pursuit*, Francis Crick, Nobel laureate and co-discoverer of the structure of DNA, writes, “Biologists must constantly keep in mind that what they see was not designed, but rather evolved.”

The biological community thinks it has accounted for the apparent design in nature through the Darwinian mechanism of random mutation and natural selection. The point to appreciate, however, is that in accounting for the apparent design in nature, biologists regard themselves as having made a successful scientific argument against actual design. This is important, because for a claim to be scientifically falsifiable, it must have the possibility of being true. Scientific refutation is a double-edged sword. Claims that are refuted scientifically may be wrong, but they are not necessarily wrong — they cannot simply be dismissed out of hand.

To see this, consider what would happen if microscopic examination revealed that every cell was inscribed with the phrase “Made by Yahweh.” Of course cells don’t have “Made by Yahweh” inscribed on them, but that’s not the point. The point is that we wouldn’t know this unless we actually looked at cells under the microscope. And if they were so inscribed, one would have to entertain the thought, as a scientist, that they actually were made by Yahweh. So even those who do not believe in it tacitly admit that design always remains a live option in biology. A priori prohibitions against design are philosophically unsophisticated and easily countered. Nonetheless, once we admit that design cannot be excluded from science without argument, a weightier question remains: Why should we want to admit design into science?

To answer this question, let us turn it around and ask instead, Why shouldn’t we want to admit design into science? What’s wrong with explaining something as designed by an intelligent agent? Certainly there are many everyday occurrences that we explain by appealing to design. Moreover, in our workaday lives it is absolutely crucial to distinguish accident from design. We demand answers to such questions as, Did she fall or was she pushed? Did someone die accidentally or commit suicide? Was this song conceived independently or was it plagiarized? Did someone just get lucky on the stock market or was there insider trading? Not only do we demand answers to such questions, but entire industries are devoted to drawing the distinction between accident and design. Here we can include forensic science, intellectual property law, insurance claims investigation, cryptography, and random number generation — to name but a few. Science itself needs to draw this distinction to keep itself honest. Just last January there was a report in *Science* that a Medline web search uncovered a “paper published in *Zentralblatt für Gynäkologie* in 1991 [containing] text that is almost identical to text from a paper published in 1979 in the Journal of Maxillofacial Surgery.” Plagiarism and data falsification are far more common in science than we would like to admit. What keeps these abuses in check is our ability to detect them.

If design is so readily detectable outside science, and if its detectability is one of the key factors keeping scientists honest, why should design be barred from the content of science? Why do Dawkins and Crick feel compelled to constantly remind us that biology studies things that only appear to be designed, but that in fact are not designed? Why couldn't biology study things that are designed?

The biological community's response to these questions has been to resist design absolutely. The worry is that for natural objects (unlike human artifacts) the distinction between design and non-design cannot be reliably drawn. Consider, for instance, the following remark by Darwin in the concluding chapter of his Origin of Species: "Several eminent naturalists have of late published their belief that a multitude of reputed species in each genus are not real species; but that other species are real, that is, have been independently created. ... Nevertheless they do not pretend that they can define, or even conjecture, which are the created forms of life, and which are those produced by secondary laws. They admit variation as a vera causa in one case, they arbitrarily reject it in another, without assigning any distinction in the two cases." Biologists worry about attributing something to design (here identified with creation) only to have it overturned later; this widespread and legitimate concern has prevented them from using intelligent design as a valid scientific explanation.

Though perhaps justified in the past, this worry is no longer tenable. There now exists a rigorous criterion — complexity-specification—for distinguishing intelligently caused objects from unintelligently caused ones. Many special sciences already use this criterion, though in a pre-theoretic form (e.g., forensic science, artificial intelligence, cryptography, archeology, and the Search for Extra-Terrestrial Intelligence). The great breakthrough in philosophy of science and probability theory of recent years has been to isolate and make precise this criterion. Michael Behe's criterion of irreducible complexity for establishing the design of biochemical systems is a special case of the complexity-specification criterion for detecting design (cf. Behe's book *Darwin's Black Box*).

What does this criterion look like? Although a detailed explanation and justification is fairly technical (for a full account see my book *The Design Inference*, published by Cambridge University Press), the basic idea is straightforward and easily illustrated. Consider how the radio astronomers in the movie Contact detected an extraterrestrial intelligence. This movie, which came out last year and was based on a novel by Carl Sagan, was an enjoyable piece of propaganda for the SETI research program—the Search for Extra-Terrestrial Intelligence. In the movie, the SETI researchers found extraterrestrial intelligence. (The nonfictional researchers have not been so successful.)

How, then, did the SETI researchers in Contact find an extraterrestrial intelligence? SETI researchers monitor millions of radio signals from outer space. Many natural objects in space (e.g., pulsars) produce radio waves. Looking for signs of design among all these naturally produced radio signals is like looking for a needle in a haystack. To sift through the haystack, SETI researchers run the signals they monitor through computers programmed with pattern-matchers. As long as a signal doesn't match one of the pre-set patterns, it will pass through the pattern-matching sieve (even if it has an intelligent source). If, on the other hand, it does match one of these patterns, then, depending on the pattern matched, the SETI researchers may have cause for celebration.
The SETI researchers in *Contact* found the following signal:

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11
1111111111

In this sequence of 1126 bits, 1's correspond to beats and 0's to pauses. This sequence represents the prime numbers from 2 to 101,where a given prime number is represented by the corresponding number of beats (i.e., 1's), and the individual prime numbers are separated by pauses (i.e., 0's). The SETI researchers in *Contact* took this signal as decisive confirmation of an extraterrestrial intelligence. What is it about this signal that decisively indicates design? Whenever we infer design, we must establish two things — complexity and specification. Complexity ensures that the object in question is not so simple that it can readily be explained by chance. Specification ensures that this object exhibits the type of pattern that is the trademark of intelligence.

To see why complexity is crucial for inferring design, consider the following sequence of bits:
110111011111

These are the first twelve bits in the previous sequence representing the prime numbers 2, 3, and 5 respectively. Now it is a sure bet that no SETI researcher, if confronted with this twelve-bit sequence, is going to contact the science editor at the *New York Times*, hold a press conference, and announce that an extraterrestrial intelligence has been discovered. No headline is going to read, "Aliens Master First Three Prime Numbers!"

The problem is that this sequence is much too short (i.e., has too little complexity) to establish that an extraterrestrial intelligence with knowledge of prime numbers produced it. A randomly beating radio source might by chance just happen to put out the sequence "110111011111." A sequence of 1126 bits representing the prime numbers from 2 to 101, however, is a different story. Here the sequence is sufficiently long (i.e., has enough complexity) to confirm that an extraterrestrial intelligence could have produced it.

Even so, complexity by itself isn't enough to eliminate chance and indicate design. If I flip a coin 1,000 times, I'll participate in a highly complex (or what amounts to the same thing, highly improbable) event. Indeed, the sequence I end up flipping will be one in a trillion trillion trillion . . . , where the ellipsis needs twenty-two more "trillions." This sequence of coin tosses won't, however, trigger a design inference. Though complex, this sequence won't exhibit a suitable pattern. Contrast this with the sequence representing the prime numbers from 2 to 101. Not only is this sequence complex, it also embodies a suitable pattern. The SETI researcher who in the movie Contact discovered this sequence put it this way: "This isn't noise, this has structure."

What is a suitable pattern for inferring design? Not just any pattern will do. Some patterns can legitimately be employed to infer design whereas others cannot. It is easy to see the basic intuition here. Suppose an archer stands fifty meters from a large wall with bow and arrow in hand. The wall, let's say, is sufficiently large that the archer can't help but hit it. Now suppose each time the archer shoots an arrow at the wall, the archer paints a target around the arrow so that the arrow sits squarely in the bull's-eye. What can be concluded from this scenario? Absolutely nothing about the archer's ability as an archer. Yes, a pattern is being matched; but it is a pattern fixed only after the arrow has been shot. The pattern is thus purely ad hoc.

But suppose instead the archer paints a fixed target on the wall and then shoots at it. Suppose the archer shoots a hundred arrows, and each time hits a perfect bull's-eye. What can be concluded from this second scenario? Confronted with this second scenario we are obligated to infer that here is a world-class archer, one whose shots cannot legitimately be explained by luck, but rather must be explained by the archer's skill and mastery. Skill and mastery are of course instances of design.

Like the archer who fixes the target first and then shoots at it, statisticians set what is known as a rejection region prior to an experiment. If the outcome of an experiment falls within a rejection region, the statistician rejects the hypothesis that the outcome is due to chance. The pattern doesn't need to be given prior to an event to imply design. Consider the following cipher text:

nfuijolt ju jt mjlf b xfbtfm

Initially this looks like a random sequence of letters and spaces — initially you lack any pattern for rejecting chance and inferring design.
But suppose next that someone comes along and tells you to treat this sequence as a Caesar cipher, moving each letter one notch down the alphabet. Behold, the sequence now reads,

methinks it is like a weasel

Even though the pattern is now given after the fact, it still is the right sort of pattern for eliminating chance and inferring design. In contrast to statistics, which always tries to identify its patterns before an experiment is performed, cryptanalysis must discover its patterns after the fact. In both instances, however, the patterns are suitable for inferring design. Patterns divide into two types, those that in the presence of complexity warrant a design inference and those that despite the presence of complexity do not warrant a design inference. The first type of pattern is called a specification, the second a fabrication. Specifications are the non-ad hoc patterns that can legitimately be used to eliminate chance and warrant a design inference. In contrast, fabrications are the ad hoc patterns that cannot legitimately be used to warrant a design inference. This distinction between specifications and fabrications can be made with full statistical rigor (cf. *The Design Inference*).

Why does the complexity-specification criterion reliably detect design? To answer this, we need to understand what it is about intelligent agents that makes them detectable in the first place. The principal characteristic of intelligent agency is choice. Whenever an intelligent agent acts, it chooses from a range of competing possibilities.

This is true not just of humans and extraterrestrial intelligences, but of animals as well. A rat navigating a maze must choose whether to go right or left at various points in the maze. When SETI researchers attempt to discover intelligence in the radio transmissions they are monitoring, they assume an extraterrestrial intelligence could have chosen to transmit any number of possible patterns, and then attempt to match the transmissions they observe with the patterns they seek. Whenever a human being utters meaningful speech, he chooses from a range of utterable sound-combinations. Intelligent agency always entails discrimination—choosing certain things, ruling out others.

Given this characterization of intelligent agency, how do we recognize that an intelligent agent has made a choice? A bottle of ink spills accidentally onto a sheet of paper; someone takes a fountain pen and writes a message on a sheet of paper. In both instances ink is applied to paper. In both instances one among an almost infinite set of possibilities is realized. In both instances one contingency is actualized and others are ruled out. Yet in one instance we ascribe agency, in the other chance.

What is the relevant difference? Not only do we need to observe that a contingency was actualized, but we ourselves need also to be able to specify that contingency. The contingency must conform to an independently given pattern, and we must be able independently to formulate that pattern. A random ink blot is unspecifiable; a message written with ink on paper is specifiable. Wittgenstein in *Culture and Value* made the same point: "We tend to take the speech of a Chinese for inarticulate gurgling. Someone who understands Chinese will recognize language in what he hears."

In hearing a Chinese utterance, someone who understands Chinese not only recognizes that one from a range of all possible utterances was actualized, but he is also able to identify the utterance as coherent Chinese speech. Contrast this with someone who does not understand Chinese. He will also recognize that one from a range of possible utterances was actualized, but this time, because he lacks the ability to understand Chinese, he is unable to tell whether the utterance was coherent speech.

To someone who does not understand Chinese, the utterance will appear gibberish. Gibberish—the utterance of nonsense syllables uninterpretable within any natural language—always actualizes one utterance from the range of possible utterances. Nevertheless, gibberish, by corresponding to nothing we can understand in any language, also cannot be specified. As a result, gibberish is never taken for intelligent communication, but always for what Wittgenstein calls “inarticulate gurgling.”

Experimental psychologists who study animal learning and behavior employ a similar method. To learn a task an animal must acquire the ability to actualize behaviors suitable for the task as well as the ability to rule out behaviors unsuitable for the task. Moreover, for a psychologist to recognize that an animal has learned a task, it is necessary not only to observe the animal making the appropriate discrimination, but also to specify this discrimination.

Thus to recognize whether a rat has successfully learned how to traverse a maze, a psychologist must first specify which sequence of right and left turns conducts the rat out of the maze. No doubt, a rat randomly wandering a maze also discriminates a sequence of right and left turns. But by randomly wandering the maze, the rat gives no indication that it can discriminate the appropriate sequence of right and left turns for exiting the maze. Consequently, the psychologist studying the rat will have no reason to think the rat has learned how to traverse the maze. Only if the rat executes the sequence of right and left turns specified by the psychologist will the psychologist recognize that the rat has learned how to traverse the maze.

Note that complexity is implicit here as well. To see this, consider again a rat traversing a maze, but now take a very simple maze in which two right turns conduct the rat out of the maze. How will a psychologist studying the rat determine whether it has learned to exit the maze? Just putting the rat in the maze will not be enough. Because the maze is so simple, the rat could by chance just happen to take two right turns, and thereby exit the maze. The psychologist will therefore be uncertain whether the rat actually learned to exit this maze, or whether the rat just got lucky.

But contrast this now with a complicated maze in which a rat must take just the right sequence of left and right turns to exit the maze. Suppose the rat must take one hundred appropriate right and left turns, and that any mistake will prevent the rat from exiting the maze. A psychologist who sees the rat take no erroneous turns and in short order exit the maze will be convinced that the rat has indeed learned how to exit the maze, and that this was not dumb luck.

This general scheme for recognizing intelligent agency is but a thinly disguised form of the complexity-specification criterion. In general, to recognize intelligent agency we must observe a choice among competing possibilities, note which possibilities were not chosen, and then be able to specify the possibility that was chosen. What's more, the competing possibilities that were ruled out must be live possibilities, and sufficiently numerous (hence complex) so that specifying the possibility that was chosen cannot be attributed to chance.

All the elements in this general scheme for recognizing intelligent agency (i.e., choosing, ruling out, and specifying) find their counterpart in the complexity-specification criterion. It follows that this criterion formalizes what we have been doing right along when we recognize intelligent agency. The complexity-specification criterion pinpoints what we need to be looking for when we detect design.

Perhaps the most compelling evidence for design in biology comes from biochemistry. In a recent issue of *Cell* (February 8, 1998),Bruce Alberts, president of the National Academy of Sciences, remarked, "The entire cell can be viewed as a factory that contains an elaborate network of interlocking assembly lines, each of which is composed of large protein machines. . . . Why do we call the large protein assemblies that underlie cell function machines? Precisely because, like the machines invented by humans to deal efficiently with the macroscopic world, these protein assemblies contain highly coordinated moving parts."

Even so, Alberts sides with the majority of biologists in regarding the cell's marvelous complexity as only apparently designed. The Lehigh University biochemist Michael Behe disagrees. In *Darwin's Black Box* (1996), Behe presents a powerful argument for actual design in the cell. Central to his argument is his notion of irreducible complexity. A system is irreducibly complex if it consists of several interrelated parts so that removing even one part completely destroys the system's function. As an example of irreducible complexity Behe offers the standard mousetrap. A mousetrap consists of a platform, a hammer, a spring, a catch, and a holding bar. Remove any one of these five components, and it is impossible to construct a functional mousetrap.

Irreducible complexity needs to be contrasted with cumulative complexity. A system is cumulatively complex if the components of the system can be arranged sequentially so that the successive removal of components never leads to the complete loss of function. An example of a cumulatively complex system is a city. It is possible successively to remove people and services from a city until one is down to a tiny village—all without losing the sense of community, the city's "function."

From this characterization of cumulative complexity, it is clear that the Darwinian mechanism of natural selection and random mutation can readily account for cumulative complexity. Darwin's account of how organisms gradually become more complex as favorable adaptations accumulate is the flip side of the city in our example from which people and services are removed. In both cases, the simpler and more complex versions both work, only less or more effectively.

But can the Darwinian mechanism account for irreducible complexity? Certainly, if selection acts with reference to a goal, it can produce irreducible complexity. Take Behe's mousetrap. Given the goal of constructing a mousetrap, one can specify a goal-directed selection process that in turn selects a platform, a hammer, a spring, a catch, and a holding bar, and at the end puts all these components together to form a functional mousetrap. Given a pre-specified goal, selection has no difficulty producing irreducibly complex systems.

But the selection operating in biology is Darwinian natural selection. And by definition this form of selection operates without goals, has neither plan nor purpose, and is wholly undirected. The great appeal of Darwin's selection mechanism was, after all, that it would eliminate teleology from biology. Yet by making selection an undirected process, Darwin drastically reduced the type of complexity biological systems could manifest.

Henceforth biological systems could manifest only cumulative complexity, not irreducible complexity.

As Behe explains in *Darwin's Black Box*: "An irreducibly complex system cannot be produced . . . by slight, successive modifications of a precursor system, because any precursor to an irreducibly complex system that is missing a part is by definition nonfunctional. . .. Since natural selection can only choose systems that are already working, then if a biological system cannot be produced gradually it would have to arise as an integrated unit, in one fell swoop, for natural selection to have anything to act on."

For an irreducibly complex system, function is attained only when all components of the system are in place simultaneously. It follows that natural selection, if it is going to produce an irreducibly complex system, has to produce it all at once or not at all. This would not be a problem if the systems in question were simple. But they're not. The irreducibly complex biochemical systems Behe considers are protein machines consisting of numerous distinct proteins, each indispensable for function; together they are beyond what natural selection can muster in a single generation.

One such irreducibly complex biochemical system that Behe considers is the bacterial flagellum. The flagellum is a whip-like rotary motor that enables a bacterium to navigate through its environment. The flagellum includes an acid-powered rotary engine, a stator, O-rings, bushings, and a drive shaft. The intricate machinery of this molecular motor requires approximately fifty proteins. Yet the absence of any one of these proteins results in the complete loss of motor function.

The irreducible complexity of such biochemical systems cannot be explained by the Darwinian mechanism, nor indeed by any naturalistic evolutionary mechanism proposed to date. Moreover, because irreducible complexity occurs at the biochemical level, there is no more fundamental level of biological analysis to which the irreducible complexity of biochemical systems can be referred, and at which a Darwinian analysis in terms of selection and mutation can still hope for success. Undergirding biochemistry is ordinary chemistry and physics, neither of which can account for biological information. Also, whether a biochemical system is irreducibly complex is a fully empirical question: Individually knock out each protein constituting a biochemical system to determine whether function is lost. If so, we are dealing with an irreducibly complex system. Experiments of this sort are routine in biology.

The connection between Behe's notion of irreducible complexity and my complexity-specification criterion is now straightforward. The irreducibly complex systems Behe considers require numerous components specifically adapted to each other and each necessary for function. That means they are complex in the sense required by the complexity-specification criterion

Specification in biology always makes reference in some way to an organism's function. An organism is a functional system comprising many functional subsystems. The functionality of organisms can be specified in any number of ways. Arno Wouters does so in terms of the viability of whole organisms, Michael Behe in terms of the minimal function of biochemical systems. Even Richard Dawkins will admit that life is specified functionally, for him in terms of the reproduction of genes. Thus in *The Blind Watchmaker* Dawkins writes, “Complicated things have some quality, specifiable in advance, that is highly unlikely to have been acquired by random chance alone. In the case of living things, the quality that is specified in advance is . . . the ability to propagate genes in reproduction.” So there exists a reliable criterion for detecting design strictly from observational features of the world. This criterion belongs to probability and complexity theory, not to metaphysics and theology. And although it cannot achieve logical demonstration, it does achieve a statistical justification so compelling as to demand assent. This criterion is relevant to biology. When applied to the complex, information-rich structures of biology, it detects design. In particular, we can say with the weight of science behind us that the complexity-specification criterion shows Michael Behe’s irreducibly complex biochemical systems to be designed.

What are we to make of these developments? Many scientists remain unconvinced. Even if we have a reliable criterion for detecting design, and even if that criterion tells us that biological systems are designed, it seems that determining a biological system to be designed is akin to shrugging our shoulders and saying God did it. The fear is that admitting design as an explanation will stifle scientific inquiry, that scientists will stop investigating difficult problems because they have a sufficient explanation already.

But design is not a science stopper. Indeed, design can foster inquiry where traditional evolutionary approaches obstruct it. Consider the term “junk DNA.” Implicit in this term is the view that because the genome of an organism has been cobbled together through a long, undirected evolutionary process, the genome is a patchwork of which only limited portions are essential to the organism. Thus on an evolutionary view we expect a lot of useless DNA. If, on the other hand, organisms are designed, we expect DNA, as much as possible, to exhibit function. And indeed, the most recent findings suggest that designating DNA as “junk” merely cloaks our current lack of knowledge about function. For instance, in a recent issue of the *Journal of Theoretical Biology*, John Bodnar describes how “non-

coding DNA in eukaryotic genomes encodes a language which programs organismal growth and development." Design encourages scientists to look for function where evolution discourages it.
Or consider vestigial organs that later are found to have a function after all. Evolutionary biology texts often cite the human coccyx as a "vestigial structure" that hearkens back to vertebrate ancestors with tails. Yet if one looks at a recent edition of Gray's Anatomy, one finds that the coccyx is a crucial point of contact with muscles that attach to the pelvic floor. The phrase "vestigial structure" often merely cloaks our current lack of knowledge about function. The human appendix, formerly thought to be vestigial, is now known to be a functioning component of the immune system.

Admitting design into science can only enrich the scientific enterprise. All the tried and true tools of science will remain intact. But design adds a new tool to the scientist's explanatory tool chest. Moreover, design raises a whole new set of research questions. Once we know that something is designed, we will want to know how it was produced, to what extent the design is optimal, and what is its purpose. Note that we can detect design without knowing what something was designed for. There is a room at the Smithsonian filled with objects that are obviously designed but whose specific purpose anthropologists do not understand.

Design also implies constraints. An object that is designed functions within certain constraints. Transgress those constraints and the object functions poorly or breaks. Moreover, we can discover those constraints empirically by seeing what does and doesn't work. This simple insight has tremendous implications not just for science but also for ethics. If humans are in fact designed, then we can expect psychosocial constraints to be hardwired into us. Transgress those constraints, and we as well as our society will suffer. There is plenty of empirical evidence to suggest that many of the attitudes and behaviors our society promotes undermine human flourishing. Design promises to reinvigorate that ethical stream running from Aristotle through Aquinas known as natural law.

By admitting design into science, we do much more than simply critique scientific reductionism. Scientific reductionism holds that everything is reducible to scientific categories. Scientific reductionism is self-refuting and easily seen to be self-refuting. The existence of the world, the laws by which the world operates, the intelligibility of the world, and the unreasonable effectiveness of mathematics for comprehending the world are just a few of the questions that science raises, but that science is incapable of answering.

Simply critiquing scientific reductionism, however, is not enough. Critiquing reductionism does nothing to change science. And it is science that must change. By eschewing design, science has for too long operated with an inadequate set of conceptual categories. This has led to a constricted vision of reality, skewing how science understands not just the world, but also human beings.

Martin Heidegger remarked in *Being and Time* that “a science’s level of development is determined by the extent to which it is capable of a crisis in its basic concepts.” The basic concepts with which science has operated these last several hundred years are no longer adequate, certainly not in an information age, certainly not in an age where design is empirically detectable. Science faces a crisis of basic concepts. The way out of this crisis is to expand science to include design. To admit design into science is to liberate science, freeing it from restrictions that can no longer be justified.

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Bill Dembski - Freedom, Technology, Education

Daily, hundreds of different choices present themselves to us. It seems this would be an overwhelming task, but our brain and body work together to make the decision-making process much easier than it seems.

We operate from nine human design centers that take the information we have access to and crunch the numbers so that we can make the best decision for ourselves.

If you would like to learn more about the individual characteristics of these energy centers and how they present themselves in our lives, read on.

3 Ways in Which Science Suggests a Higher Power Created the Universe

People have long debated how the universe was created. Was our world created slowly over time thanks to coincidences and evolution — or was there a God at work?

Science has actually hinted at the idea of an intelligence behind the universe's creation in three major ways.

An Ordered Universe

For hundreds of years, scientists have worked at trying to uncover the mysteries of the universe.

Once upon a time, many thought that the universe and space was chaotic, with no rhyme or reason. However, scientists now believe that the universe was designed in an orderly fashion. Everything has its place, and everything works together to form life.

Fine-Tuning of Constants

The physical constants of our universe are remarkably precise for life to exist. For example, if gravity were slightly stronger or weaker, stars might not form properly, making life impossible.

This fine-tuning leads some scientists and theologians to argue that a designer must have set these constants deliberately.

The improbability of these constants occurring by chance raises questions about randomness versus intentionality. Many see this as evidence of a divine creator who established the conditions necessary for life.

The Anthropic Principle

The anthropic principle states that the universe's laws and constants must allow for human existence; otherwise, we wouldn't be here to observe them. This principle suggests that our universe is uniquely suited for life, which some interpret as evidence of intentional design.

Critics argue that this principle merely reflects our observational bias; however, proponents maintain that such precise conditions point toward a creator who crafted the universe with humanity in mind.

A Balanced Universe

Though many aspects of space, stars, and galaxies may seem completely unorganized, this actually isn't the case.

The universe is balanced. As a result, some scientists have begun to hint that this could be a sign that a God or Creator is behind the assurance of this balance throughout all parts of the universe.

Balance Creates Life

Scientists have explained that this balance seen on Earth has allowed life to thrive over millions of years.

For example, if gravity — one of the main forces of nature on Earth — were just slightly off, life on Earth wouldn't exist, as the formation of the sun and stars near us would be off.

Evolutionary Biology

Evolutionary biology explains how life adapts and evolves over time through natural selection. However, many believers argue that evolution does not preclude God's role in creation but rather complements it by illustrating how God may have chosen to create life through natural processes.

This perspective allows for a harmonious relationship between faith and science, suggesting that God could work through evolution to bring about the diversity of life we see today.

The Earth Is Positioned Just Right

Meanwhile, scientists have also pointed out that the Earth is tilted at exactly the right angle it needs to be to allow for water — and therefore life — to thrive.

The Earth also rotates at exactly the right speed to ensure we get days and nights, which can help nature grow in an easy and beneficial way.

The Structure of DNA

The balance of the universe has caused many scientists to begin to point to some intelligence seen throughout Earth and space.

However, other scientists have theorized that an intelligent God or Creator could be behind life thanks to ongoing studies done on DNA.

Studying Genetic Codes

DNA carries all of the genetic codes of living creatures, such as humans and animals. However, this DNA is incredibly complex. Studies are still attempting to unravel more of DNA's secrets.

Because of this complexity, new studies have begun to liken DNA to computer code. This has further caused researchers to theorize about the universe and religion.

The Improbability of Life

The emergence of complex life forms from simple molecules is statistically improbable without specific conditions being met. Many scientists argue that such improbability points toward intelligent design rather than random chance.

This perspective aligns with theological views asserting that God intentionally created life within a framework conducive to its development.

The Mass Extinction Events

Throughout Earth's history, several mass extinction events have wiped out a large portion of life on the planet. However, the causes of mass extinctions remain less specific, with some scientists suggesting they may be linked to volcanic activity, climate change, or even extraterrestrial factors.

Coincidence or an Intelligent God?

After scientists discovered the double helix formation of DNA in 1953, researchers began to really analyze this remarkable part of human life.

They found that DNA strands are incredibly complex. Some have stated that these sequences look like computer code written by a programmer. As a result, a debate has begun about whether DNA is the result of coincidence and evolution — or an intelligent Creator.

Quantum Mechanics & Consciousness

Quantum mechanics introduces fascinating concepts about reality and observation. Some theories suggest that consciousness plays a role in shaping physical reality at quantum levels.

This intertwining of consciousness with existence prompts discussions about whether a divine mind influences the universe.

The implications are profound: if consciousness is integral to reality, could it be reflective of a higher consciousness—God—who imbues the universe with purpose and meaning?

This perspective invites exploration into the relationship between science and spirituality.

DNA Is Too Advanced

Proponents of this computer code theory believe that DNA sequences are too advanced for them to have happened naturally or through random evolution.

Many people have come out in support of the theory that DNA proves an intelligent God is behind life's creation. Even Bill Gates has stated that DNA is an advanced computer program.

The Origin of Information

Information is fundamental to life; DNA carries complex instructions for biological functions. The origin of such intricate information poses challenges for purely naturalistic explanations.

Many argue that information requires an intelligent source—much like how human-designed systems arise from conscious thought—suggesting God's involvement in imparting order to chaos.

The Fibonacci Sequence in Nature

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This mathematical pattern appears everywhere—in pinecones, sunflowers, and galaxies. It's linked to the "golden ratio," a proportion considered aesthetically pleasing. Why does nature follow this pattern so over and over? It's as if the universe has a hidden code waiting to be deciphered.

Moral Law & Cosmic Order

Philosophers often debate whether moral laws exist independently or are socially constructed. Some posit that these laws imply a higher moral authority—God—who instills universal principles within humanity.

This notion connects ethical frameworks with cosmic order, suggesting that just as physical laws govern the universe's behavior, moral laws reflect divine intent guiding human actions.

The Origin of Life

One of science's oldest and most fundamental mysteries is how life first arose on Earth. While scientists understand the basic building blocks of life, they still need to figure out how these molecules came together to form self-replicating organisms. Even though scientists believe life originates from an infinite point, they speculate a definite beginning.

Human Connection

Human connection is the ability to form meaningful relationships with others. These relationships can involve emotional intimacy, shared experiences, and mutual support. Studies have shown that strong social connections are essential for mental and physical health. Pursuing human connection is a fundamental aspect of the human experience.

The Existence of Free Will

Do we genuinely make choices, or are we just following predetermined paths? Neuroscience suggests our brains make decisions before we're conscious of them. Yet we feel like free agents. This paradox touches on fundamental questions about human nature, responsibility, and the essence of self.

The Quest for Meaning

Science excels at explaining "how" but struggles with "why." Our search for significance often leads to spiritual exploration, as if an inner compass guides us toward our Creator. This universal human yearning hints at a higher calling, perhaps originating from God. The peace people find connecting with God suggests He is the source.

The Human Soul

The concept of the soul is a central tenet of many religions and philosophies. It is often described as an immaterial or spiritual entity that gives life to the body and continues to exist after death. This intangible yet deeply felt aspect of human existence points to a divine spark within us, connecting us to something greater.

The Power of Prayer

Countless individuals attest to prayer’s transformative effects. From inner peace to physical healing, the impact of communicating with God transcends scientific understanding. Whether or not you believe in the power of prayer, it is a practice that people of all cultures and faiths have embraced throughout history.

Prophetic Visions and Divine Revelations

Religious texts across faiths describe prophets receiving messages from God. These divine communications have shaped civilizations and continue to guide millions. Some scientists assume that they are God's channel to provide answers to human questions. However, divine revelations’ intense wisdom and foresight again and again surpass human understanding, pointing to a higher source.

Miracles and Healings

While skeptics argue that miracles can be explained by chance or coincidence, believers maintain that they are evidence of a higher power. The concept of miracles has played a huge role in cultural and religious beliefs throughout history. Miracles are events that defy natural explanation and are many times attributed to divine intervention.

The Afterlife Debate

Even though scientific inquiry has focused on the physical aspects of existence, many people believe in a spiritual or metaphysical dimension that transcends the material world. Furthermore, science is currently changing perceptions to say that since everything in the universe needs to be preserved, our “souls” must go somewhere.

Analyzing the Creation of the Universe

The universe's balance and the structure of DNA aren't the only reasons why some scientists have begun to believe a God or intelligent Creator is behind the creation of the universe.

The idea of the creation of the universe itself has prompted many to believe that a finite beginning to life exists — and this beginning was first started by God.

Creation's Intricate Design

Many see God's handiwork in nature's intricacies, from DNA's complexity to galaxies' vastness. They argue that the harmony and beauty in creation reflect an intelligent designer rather than random chance and suggest that these features must result from a creator's intentional design.

The Big Bang Theory

The Big Bang Theory is the theory of the creation of the universe. Scientists have theorized that the universe is continuing to expand outward. Therefore, the universe has a starting point. It has a birth.

This has prompted many scientists to wonder what officially caused this "birth." Though many theories have been brought up, they still remain ideas and none have been officially proven through science.

Cosmic Background Radiation

Cosmic background radiation is considered residual heat from the Big Bang, permeating space as a faint glow. Its discovery provides strong evidence for the Big Bang Theory and suggests an initial moment of creation.

Some interpret this radiation as God's fingerprints on creation—a remnant of His creative act echoing through time and space.

The Laws of Thermodynamics

The laws of thermodynamics govern energy transfer in our universe. The first law states that energy cannot be created or destroyed; it only changes forms. This raises questions about where the initial energy came from—leading many to contemplate a divine source.

If energy cannot originate from nothingness, then it stands to reason that an eternal being—God—must have initiated this process, sustaining it throughout cosmic history.

The Role of Dark Matter & Energy

Dark matter and dark energy constitute most of the universe's mass-energy content yet remain largely mysterious to scientists. Their existence hints at complexities beyond current understanding, prompting questions about their origins.

Some theologians see this mystery as indicative of God's handiwork—an acknowledgment that not all aspects of creation are fully comprehensible by human intellect but still reflect divine wisdom.

Multiverse Theory

Some scientists propose a multiverse theory, suggesting our universe is just one among countless others with varying laws and constants. While this theory complicates traditional notions of creation, it also raises questions about what governs these universes' existence.

Could there be a higher power orchestrating multiple realities? This possibility invites deeper contemplation about God's role in creating not just one universe but potentially infinite variations.

The Universe Is Expanding

Therefore, if the universe is expanding, then this means that planets and galaxies are moving away, farther apart, from some sort of a beginning.

It's this beginning that has excited scientists — and allowed them to believe that God may have been the switch to start this universe in the first place.

Interconnectedness of All Things

Modern science increasingly recognizes interconnectedness across ecosystems and cosmic phenomena—from quantum entanglement to ecological balance. This web suggests an underlying unity in creation often attributed to a divine source fostering connection among all things.

Many see this interconnectedness as reflective of God's nature—a reminder that every element within the universe serves a purpose within His grand design.

While science offers various explanations for how the universe came into being, many still find room for faith in divine involvement throughout these processes.

Whether through ancient texts or modern discoveries, the dialogue between science and spirituality continues to inspire curiosity and wonder about our origins and purpose.

Intelligent design

Intelligent design (**ID**) is a pseudoscientific argument for the existence of God, presented by its proponents as "an evidence-based scientific theory about life's origins".[1][2][3][4][5] Proponents claim that "certain features of the universe and of living things are best explained by an intelligent cause, not an undirected process such as natural selection."[6] ID is a form of creationism that lacks empirical support and offers no testable or tenable hypotheses, and is therefore not science.[7][8][9] The leading proponents of ID are associated with the Discovery Institute, a Christian, politically conservative think tank based in the United States.[n 1]

Although the phrase *intelligent design* had featured previously in theological discussions of the argument from design,[10] its first publication in its present use as an alternative term for creationism was in *Of Pandas and People*,[11][12] a 1989 creationist textbook intended for high school biology classes. The term was substituted into drafts of the book, directly replacing references to *creation science* and *creationism*, after the 1987 Supreme Court's *Edwards v. Aguillard* decision barred the teaching of creation science in public schools on constitutional grounds.[13] From the mid-1990s, the intelligent design movement (IDM), supported by the Discovery Institute,[14] advocated inclusion of intelligent design in public school biology curricula.[7] This led to the 2005 *Kitzmiller v. Dover Area School District* trial, which found that intelligent design was not science, that it "cannot uncouple itself from its creationist, and thus religious, antecedents", and that the public school district's promotion of it therefore violated the Establishment Clause of the First Amendment to the United States Constitution.[15]

ID presents two main arguments against evolutionary explanations: irreducible complexity and specified complexity, asserting that certain biological and informational features of living things are too complex to be the result of natural selection. Detailed scientific examination has rebutted several examples for which evolutionary explanations are claimed to be impossible.

ID seeks to challenge the methodological naturalism inherent in modern science,[2][16] though proponents concede that they have yet to produce a scientific theory.[17] As a positive argument against evolution, ID proposes an analogy between natural systems and human artifacts, a version of the theological argument from design for the existence of God.[1][n 2] ID proponents then conclude by analogy that the complex features, as defined by ID, are evidence of design.[18][n 3] Critics of ID find a false dichotomy in the premise that evidence against evolution constitutes evidence for design.[19][20]

History

Origin of the concept

See also: Creation science, Teleological argument, and Watchmaker analogy

In 1910, evolution was not a topic of major religious controversy in America, but in the 1920s, the fundamentalist–modernist controversy in theology resulted in fundamentalist Christian opposition to teaching evolution and resulted in the origins of modern creationism.[21] As a result, teaching of evolution was effectively suspended in U.S. public schools until the 1960s, and when evolution was then reintroduced into the curriculum, there was a series of court cases in which attempts were made to get creationism taught alongside evolution in science classes. Young Earth creationists (YECs) promoted "creation science" as "an alternative scientific explanation of the world in which we live". This frequently invoked the argument from design to explain complexity in nature as supposedly demonstrating the existence of God.[18]

The argument from design, also known as the teleological argument or "argument from intelligent design", has been presented by theologists for centuries.[22] Thomas Aquinas presented ID in his fifth proof of God's existence as a syllogism.[n 2] In 1802, William Paley's *Natural Theology* presented examples of intricate purpose in organisms. His version of the watchmaker analogy argued that a watch has evidently been designed by a craftsman and that it is supposedly just as evident that the complexity and adaptation seen in nature must have been designed. He went on to argue that the perfection and diversity of these designs supposedly shows the designer to be omnipotent and that this can supposedly only be the Christian god.[23] Like "creation science", intelligent design centers on Paley's religious argument from design,[18] but while Paley's natural theology was open to deistic design through God-given laws, intelligent design seeks scientific confirmation of repeated supposedly miraculous interventions in the history of life.[21] "Creation science" prefigured the intelligent design arguments of irreducible complexity, even featuring the bacterial flagellum. In the United States, attempts to introduce "creation science" into schools led to court rulings that it is religious in nature and thus cannot be taught in public school science classrooms. Intelligent design is also presented as science and shares other arguments with "creation science" but avoids literal Biblical references to such topics as the biblical flood story or using Bible verses to estimate the age of the Earth.[18]

Barbara Forrest writes that the intelligent design movement began in 1984 with the book *The Mystery of Life's Origin: Reassessing Current Theories*, co-written by the creationist and chemist Charles B. Thaxton and two other authors and published by Jon A. Buell's Foundation for Thought and Ethics.[24]

In March 1986, Stephen C. Meyer published a review of this book, discussing how information theory could suggest that messages transmitted by DNA in the cell show "specified complexity" and must have been created by an intelligent agent.[25] He also argued that science is based upon "foundational assumptions" of naturalism that were as much a matter of faith as those of "creation theory".[26] In November of that year, Thaxton described his reasoning as a more sophisticated form of Paley's argument from design.[27] At a conference that Thaxton held in 1988 ("Sources of Information Content in DNA"), he said that his intelligent cause view was compatible with both metaphysical naturalism and supernaturalism.[28]

Intelligent design avoids identifying or naming the intelligent designer—it merely states that one (or more) must exist—but leaders of the movement have said the designer is the Christian God.[29][n 4][n 5] Whether this lack of specificity about the designer's identity in public discussions is a genuine feature of the concept – or just a posture taken to avoid alienating those who would separate religion from the teaching of science – has been a matter of great debate between supporters and critics of intelligent design. The Kitzmiller v. Dover Area School District court ruling held the latter to be the case.

Origin of the term

See also: Timeline of intelligent design

Since the Middle Ages, discussion of the religious "argument from design" or "teleological argument" in theology, with its concept of "intelligent design", has persistently referred to the theistic Creator God. Although ID proponents chose this provocative label for their proposed alternative to evolutionary explanations, they have de-emphasized their religious antecedents and denied that ID is natural theology, while still presenting ID as supporting the argument for the existence of God.[10][30]

While intelligent design proponents have pointed out past examples of the phrase *intelligent design* that they said were not creationist and faith-based, they have failed to show that these usages had any influence on those who introduced the label in the intelligent design movement.[30][31][32]

Variations on the phrase appeared in Young Earth creationist publications: a 1967 book co-written by Percival Davis referred to "design according to which basic organisms were created". In 1970, A. E. Wilder-Smith published *The Creation of Life: A Cybernetic Approach to Evolution*. The book defended Paley's design argument with computer calculations of the improbability of genetic sequences, which he said could not be explained by evolution but required "the abhorred necessity of divine intelligent activity behind nature", and that "the same problem would be expected to beset the relationship between the designer behind nature and the intelligently designed part of nature known as man."[33] In a 1984 article as well as in his affidavit to *Edwards v. Aguillard*, Dean H. Kenyon defended creation science by stating that "biomolecular systems require intelligent design and engineering know-how", citing Wilder-Smith. Creationist Richard B. Bliss used the phrase "creative design" in *Origins: Two Models: Evolution, Creation* (1976), and in *Origins: Creation or Evolution* (1988) wrote that "while evolutionists are trying to find non-intelligent ways for life to occur, the creationist insists that an intelligent design must have been there in the first place."[34]

Watchmaker analogy

The **watchmaker analogy** or **watchmaker argument** is a teleological argument, an argument for the existence of God. In broad terms, the watchmaker analogy states that just as it is readily observed that a watch (e.g.: a pocket watch) did not come to be accidentally or on its own but rather through the intentional handiwork of a skilled watchmaker, it is also readily observed that nature did not come to be accidentally or on

its own but through the intentional handiwork of an intelligent designer. The watchmaker analogy originated in natural theology and is often used to argue for the pseudoscientific concept of intelligent design. The analogy states that a design implies a designer, by an intelligent designer, i.e. a creator deity.
The watchmaker analogy was given by William Paley in his 1802 book *Natural Theology or Evidences of the Existence and Attributes of the Deity*.[1] The original analogy played a prominent role in natural theology and the "argument from design," where it was used to support arguments for the existence of God of the universe, in both Christianity and Deism. Prior to Paley, however, Sir Isaac Newton, René Descartes, and others from the time of the Scientific Revolution had each believed "that the physical laws he [each] had uncovered revealed the mechanical perfection of the workings of the universe to be akin to a watch, wherein the watchmaker is God."[2]

The 1859 publication of Charles Darwin's book on natural selection put forward an alternative explanation to the watchmaker analogy, for complexity and adaptation. In the 19th century, deists, who championed the watchmaker analogy, held that Darwin's theory fit with "the principle of uniformitarianism—the idea that all processes in the world occur now as they have in the past" and that deistic evolution "provided an explanatory framework for understanding species variation in a mechanical universe."[3]

When evolutionary biology began being taught in American high schools in the 1960s, Christian fundamentalists used versions of the argument to dispute the concepts of evolution and natural selection, and there was renewed interest in the watchmaker argument. Evolutionary biologist Richard Dawkins referred to the analogy in his 1986 book *The Blind Watchmaker* when explaining the mechanism of evolution. Others, however, consider the watchmaker analogy to be compatible with evolutionary creation, opining that the two concepts are not mutually exclusive.[*citation needed*]

History

Ancient predecessor

In the second century Epictetus argued that, by analogy to the way a sword is made by a craftsman to fit with a scabbard, so human genitals and the desire of humans to fit them together suggest a type of design or craftsmanship of the human form. Epictetus attributed this design to a type of Providence woven into the fabric of the universe, rather than to a personal monotheistic god.[4]

Scientific Revolution

The Scientific Revolution "nurtured a growing awareness" that "there were universal laws of nature at work that ordered the movement of the world and its parts."[5] Amos Yong writes that in "astronomy, the Copernican revolution regarding the heliocentrism of the solar system, Johannes Kepler's (1571–1630) three laws of planetary motion, and Isaac Newton's (1642–1727) law of universal gravitation—laws of gravitation and of motion, and notions of absolute space and time—all combined to establish the regularities of heavenly and earthly bodies".[5]

Simultaneously, the development of machine technology and the emergence of the mechanical philosophy[6] encouraged mechanical imagery unlikely to have come to the fore in previous ages.[7]

With such a backdrop, "deists suggested the watchmaker analogy: just as watches are set in motion by watchmakers, after which they operate according to their pre-established mechanisms, so also was the world begun by God as creator, after which it and all its parts have operated according to their pre-established natural laws. With these laws perfectly in place, events have unfolded according to the prescribed plan."[3] For Sir Isaac Newton, "the regular motion of the planets made it reasonable to believe in the continued existence of God".[8] Newton also upheld the idea that "like a watchmaker, God was forced to intervene in the universe and tinker with the mechanism from time to time to ensure that it continued operating in good working order". Similarly to Newton, René Descartes (1596–1650) speculated on "the cosmos as a great time machine operating according to fixed laws, a watch created and wound up by the great watchmaker".[2][9][*citation needed*]

Emergence

In philosophy, systems theory, science, and art, **emergence** occurs when a complex entity has properties or behaviors that its parts do not have on their own, and emerge only when they interact in a wider whole.

Emergence plays a central role in theories of integrative levels and of complex systems. For instance, the phenomenon of life as studied in biology is an emergent property of chemistry and physics.

In philosophy, theories that emphasize emergent properties have been called emergentism.[1]

Specified complexity

Specified complexity is a creationist argument introduced by William Dembski, used by advocates to promote the pseudoscience of intelligent design.[*citation needed*] According to Dembski, the concept can formalize a property that singles out patterns that are both *specified* and *complex*, where in Dembski's terminology, a *specified* pattern is one that admits short descriptions, whereas a *complex* pattern is one that is unlikely to occur by chance. An example cited by Dembski is a poker hand, where for example the repeated appearance of a royal flush will raise suspicion of cheating.[1] Proponents of intelligent design use specified complexity as one of their two main arguments, along with irreducible complexity.

Dembski argues that it is impossible for specified complexity to exist in patterns displayed by configurations formed by unguided processes. Therefore, Dembski argues, the fact that specified complex patterns can be found in living things indicates some kind of guidance in their formation, which is indicative of intelligence. Dembski further argues that one can show by applying no-free-lunch theorems the inability of evolutionary algorithms to select or generate configurations of high specified complexity. Dembski states that specified complexity is a reliable marker of design by an intelligent agent—a central tenet to intelligent design, which Dembski argues for in opposition to modern evolutionary theory. Specified complexity is what Dembski terms an "explanatory filter": one can recognize design by detecting **complex specified information** (**CSI**). Dembski argues that the unguided emergence of CSI solely according to known physical laws and chance is highly improbable.[2]

The concept of specified complexity is widely regarded as mathematically unsound and has not been the basis for further independent work in information theory, in the theory of complex systems, or in biology.[3][4][5] A study by Wesley Elsberry and Jeffrey Shallit states: "Dembski's work is riddled with inconsistencies, equivocation, flawed use of mathematics, poor scholarship, and misrepresentation of others' results."[6] Another objection concerns Dembski's calculation of probabilities. According to Martin Nowak, a Harvard professor of mathematics and evolutionary biology, "We cannot calculate the probability that an eye came about. We don't have the information to make the calculation."[7]

Fine-tuned universe

The fine-tuned universe is the hypothesis that, because "life as we know it" could not exist if the constants of nature – such as the electron charge, the gravitational constant and others – had been even slightly different, the universe is tuned specifically for life.[1][2][3][4] In practice, this hypothesis is formulated in terms of dimensionless physical constants.[5]

History

In 1913, chemist Lawrence Joseph Henderson wrote *The Fitness of the Environment,* one of the first books to explore fine tuning in the universe. Henderson discusses the importance of water and the environment to living things, pointing out that life as it exists on Earth depends entirely on Earth's very specific environmental conditions, especially the prevalence and properties of water.[6]

In 1961, physicist Robert H. Dicke argued that certain forces in physics, such as gravity and electromagnetism, must be perfectly fine-tuned for life to exist in the universe.[7][8] Fred Hoyle also argued for a fine-tuned universe in his 1983 book *The Intelligent Universe*,[9] writing, "The list of anthropic properties, apparent accidents of a non-biological nature without which carbon-based and hence human life could not exist, is large and impressive".[10]

Belief in the fine-tuned universe led to the expectation that the Large Hadron Collider would produce evidence of physics beyond the Standard Model, such as supersymmetry,[11] but by 2012 it had not produced evidence for supersymmetry at the energy scales it was able to probe.[12]

Motivation

Physicist Paul Davies said: "There is now broad agreement among physicists and cosmologists that the Universe is in several respects 'fine-tuned' for life. But the conclusion is not so much that the Universe is fine-tuned for life; rather it is fine-tuned for the building blocks and environments that life requires".[13] He also said that "'anthropic' reasoning fails to distinguish between minimally biophilic universes, in which life is permitted, but only marginally possible, and optimally biophilic universes, in which life flourishes because biogenesis occurs frequently".[14] Among scientists who find the evidence persuasive, a variety of natural explanations have been proposed, such as the existence of multiple universes introducing a survivorship bias under the anthropic principle.[5]

The premise of the fine-tuned universe assertion is that a small change in several of the physical constants would make the universe radically different. Stephen Hawking observed: "The laws of science, as we know them at present, contain many fundamental numbers, like the size of the electric charge of the electron and the ratio of the masses of the proton and the electron. ... The remarkable fact is that the values of these numbers seem to have been very finely adjusted to make possible the development of life".[4]

For example, if the strong nuclear force were 2% stronger than it is (i.e. if the coupling constant representing its strength were 2% larger) while the other constants were left unchanged, diprotons would be stable; according to Davies, hydrogen would fuse into them instead of deuterium and helium.[15] This would drastically alter the physics of stars, and presumably preclude the existence of life similar to what we observe on Earth. The diproton's existence would short-circuit the slow fusion of hydrogen into deuterium. Hydrogen would fuse so easily that it is likely that all the universe's hydrogen would be consumed in the first few minutes after the Big Bang.[15] This "diproton argument" is disputed by other physicists, who calculate that as long as the increase in strength is less than 50%, stellar fusion could occur despite the existence of stable diprotons.[16]

The precise formulation of the idea is made difficult by the fact that it is not yet known how many independent physical constants there are. The standard model of particle physics has 25 freely adjustable parameters and general relativity has one more, the cosmological constant, which is known to be nonzero but profoundly small in value. Because physicists have not developed an empirically successful theory of quantum gravity, there is no known way to combine quantum mechanics, on which the standard model depends, and general relativity.[17]

Without knowledge of this more complete theory suspected to underlie the standard model, it is impossible to definitively count the number of truly independent physical constants. In some candidate theories, the number of independent physical constants may be as small as one. For example, the cosmological constant may be a fundamental constant but attempts have also been made to calculate it from other constants, and according to the author of one such calculation, "the small value of the cosmological constant is telling us that a remarkably precise and totally unexpected relation exists among all the parameters of the Standard Model of particle physics, the bare cosmological constant and unknown physics".[17]

The **International Society for Complexity, Information, and Design** (**ISCID**) was a creationism advocacy organization that described itself as "a cross-disciplinary professional society that investigates complex systems apart from external programmatic constraints like materialism, naturalism, or reductionism."[1][2] It was founded and led by figures associated with the intelligent design movement, such as William A. Dembski and Michael Behe.[3]

PCID peer review controversy

[edit]

ISCID's journal, *Progress in Complexity, Information, and Design* has been cited as an example of a journal set up by intelligent design proponents to publish articles promoting intelligent design without a peer review process with sufficient impartiality and rigor.[13][14][2][15] ISCID fellows who comprised *PCID*'s reviewers were characterized as "ardent supporters of intelligent design."[13]

ISCID's peer review policy for *PCID* was based on ISCID Fellow Frank Tipler's article covering what he saw as problems with traditional peer review processes.[16] ISCID required that for articles to be accepted into the archive, they "need to meet basic scholarly standards and be relevant to the study of complex systems." Once in the archive, articles only needed to be approved by a single ISCID Fellow in order to be published.[17] ISCID says that this policy is designed to provide peer review for quality without squelching paradigm changing theories.[18] However, the American Association for the Advancement of Science contended that review processes such as *PCID*'s were different from the accepted standard of peer review, where "reviewers are experts in the relevant scientific fields who have no conflict of interest with or especially close personal relationships to the authors or requestors."[19]

Seahorses are easily recognized by their unique shape, horse-like heads, and curling tails. These enchanting creatures dwell in shallow tropical and temperate waters across the globe, often found in seagrass beds, coral reefs, and mangroves.

One of the most fascinating aspects of seahorse biology is the male's ability to become pregnant and give birth. Their prehensile tails allow them to anchor themselves in their environment, facilitating camouflage and aiding in ambushing prey.

The extraordinary characteristics and undeniable charm of the Mandarin Fish, Beluga, and Seahorse exemplify the rich diversity and beauty of marine life, showcasing the wonders of our planet's oceans.

Originating from the Netherlands, the Friesian Horse is a majestic breed often associated with nobility. Their long, flowing manes and shiny black coats make them easily recognizable and visually stunning. Adorned with intricate braids and elegant decorations, Friesians enhance their regal appearance. Known for their graceful movements and proud stance, these horses excel in various equestrian disciplines, including dressage and show jumping. With gentle and calm temperaments, Friesians are excellent companions for riders of all skill levels. Their coat may shorten in summer, but they maintain their striking appearance year-round. While not native to places like Sri Lanka or Mars-like terrains, these captivating horses can be found in many parts of the world, where they leave a lasting impression.

The Orchid Mantis is a remarkable insect primarily found in the rainforests of Southeast Asia. Its flower-like appearance serves as an ingenious camouflage, attracting unsuspecting prey. With a pristine white body accented by soft pink hues, the Orchid Mantis mimics the look of an orchid, showcasing nature’s artistry in creating exquisite and adaptable life forms.