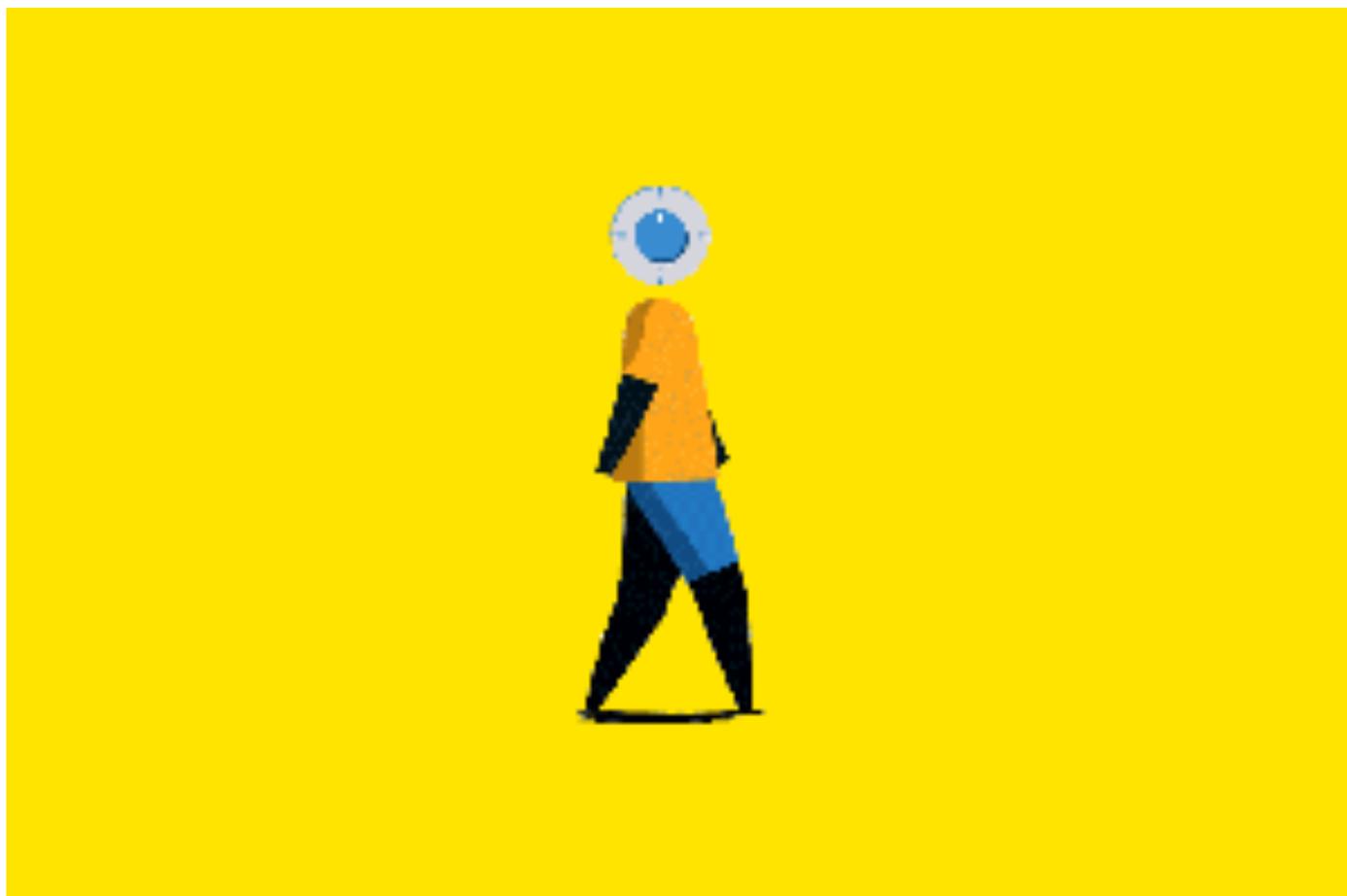


# Take control of your brain's master switch to optimise how you think

The discovery that a small blue blob of neurons, the locus coeruleus, controls your mode of thinking suggests ways to increase learning, creativity, focus and alertness



Place a finger on the back of your skull, at a point roughly

level with the tops of your ears. Here, deep beneath the hair, skin and bone, near a fluid-filled cavity in the root of your brain, lies a small bundle of pigmented cells the colour of lapis lazuli. This is the [locus coeruleus](#) – Latin for “blue dot”. It measures just a few millimetres, but its diminutive size belies its power over your thoughts.

Research has revealed that the structure is instrumental in coordinating our mental processing. Sometimes labelled the brain’s “master switch”, it is perhaps better imagined as a gearbox. “It can set the pace of your brain to suit the specific kind of mental work you are doing,” says neuroscience researcher turned [writer Mithu Storoni](#). When it is in the right gear, we feel pleasantly engaged in the task at hand. Often, however, it can get stuck in the wrong one, leading either to dreamy procrastination or frenzied frustration.

## [Unravelling the secrets of the vagus nerve will revolutionise medicine](#)

Until recently, we knew very little about the ways to control these transitions, but that is changing. It turns out that the brain’s little blue dot may be trainable – with immediate consequences for cognition and mental well-being. This means that, with the right techniques, you can change gears, influencing your mental state, from how well you focus and the levels of stress you feel, to your ability to make creative leaps and think on your feet.

A fair appreciation of the locus coeruleus has taken nearly two and a half centuries to emerge. The structure, which contains only up to 50,000 neurons, [was first identified](#) by Marie Antoinette's physician Félix Vicq d'Azyr in the late 18th century, after he noted a small blue stain in the brainstem, the mass of neural tissue joining the cerebrum to the spinal cord. Exactly what this little blue dot did, however, remained an unexplored mystery until well into the 20th century, even after Japanese researchers in the 1940s observed in monkeys that [damage to this structure](#) results in a loss of consciousness.

[Dishabituation: How to trick your brain to find more joy in life](#)

## [Learning a psychological trick to overcome your brain's tendency to stop noticing things could help you love your old clothes, notice the effects of climate change and fix gender biases, says neuroscientist Tali Sharot](#)

Subsequent experiments revealed that the power of the locus coeruleus is intimately tied to its distinctive appearance. It is the brain's primary producer of a neurotransmitter called noradrenaline, or norepinephrine, which it stores in blue-tinged bundles. When a cell within the locus coeruleus becomes active, it releases those bundles along its projections to other neurons within the brain, where the noradrenaline modulates their electrical activity in response to signals from other cells. "It makes it more likely that a cell will 'spike' when it gets the next input, and it makes any spike more forceful and impactful," says [James "Mac" Shine](#) at the University of Sydney, Australia. In other words, cells become more reactive, and the result is enhanced communication. "You're making it much easier for a message to be passed [between brain regions]," he says.

This directly affects our alertness – or arousal, as scientists sometimes put it. "Noradrenaline is one of the most important determinants of arousal," says [Storoni](#).

Nevertheless, for a long time, the full power of the locus coeruleus went unrecognised. It was thought to be a [switch that flips on](#) when we are stressed or frightened – triggering

a fight-or-flight response – but that does little at other times. This view partly arose because experiments struggled to measure subtle fluctuations in its activity. We now have much better means of capturing those nuances.

## Your brain's blue dot

Today, sophisticated brain imaging can watch the blue dot in action, a feat that was once impossible due to its size and location. More often, however, proxy measures are used to monitor the area's activity. The locus coeruleus is [directly connected to changes in the pupils of our eyes](#): the busier it becomes, the wider they dilate. Tracking these movements while keeping light levels constant therefore offers a window on its activity. Microscopic investigations, meanwhile, have shown that the dot [isn't a uniform structure](#) as was once thought. "There is much more anatomical specificity," says [Susan Sara](#) at the College of France in Paris, which might help explain how it coordinates different patterns of brain activity.

This research has now reached a critical mass, with multiple scientific papers calling for a [greater appreciation of the locus coeruleus](#). Of particular interest is the discovery that it has [four different modes of activity](#), each with distinct effects on our thinking and behaviour. It is this that led Storoni to describe the blue dot as the brain's "gear system" in her new book [Hyperefficient: Optimise your brain to](#)

[transform the way you work.](#)

When you are asleep, your brain's locus coeruleus is in Gear 0, an inactive state...

John MacLean/Millennium Images, UK

According to this metaphor, Gear 0 is the state of the locus coeruleus when you are asleep. It is almost completely silent at this point, apart from transient bursts of activity that seem to [enhance the long-term storage of memories](#). Sara discovered this effect by chance while working with [Oxana Eschenko](#) at the Max Planck Institute for Biological Cybernetics in Tübingen, Germany. They first trained rats to find their way through a maze. Then they recorded the rodents' brain activity as they slept and found that the locus coeruleus fired sporadically around 2 hours after they had

completed the task. "This activation seems to be directly correlated with the memory performance that you measure a day later," says Sara. "And if you block it, then you see a memory deficit."

## **From mind-wandering to focus**

Once we awaken, the locus coeruleus moves into Gear 1 – [a low hum of baseline activity](#). The noradrenaline eases the brain into consciousness, but it is a state of low arousal. As a result, sharp focus is lacking and we may be prone to mind-wandering.

As levels of noradrenaline increase, communication across the different regions of the brain becomes easier. Neurons in the prefrontal cortex, the area typically associated with self-control and abstract reasoning, respond first because they are sensitive to low levels of noradrenaline. Crucially, the hum of activity in the locus coeruleus is now accompanied by spikes of noradrenaline released in response to relevant stimuli. This combination of moderate baseline activity and short-lived bursts of neurotransmitter release is characteristic of Gear 2 and allows the brain to process new information more efficiently. If they are large enough, these spikes can trigger a "network reset" – a shift in focus to new and important information – which is essential for flexible thinking. "It reorganises the forebrain, precisely at the moment when you need to switch your attention and adapt

your behaviour," says Sara.

...as you wake up, the locus coeruleus moves into Gear 1, a gentle hum of activity where your concentration is low...

Nina Mangalanayagam/Millennium Images

Problems may arise when the hum turns to a roar. This is what happens in Gear 3. Here, high levels of noradrenaline streaming from the locus coeruleus can activate areas of the brain associated with emotional processing. These tend to have receptors that respond only when concentrations of the neurotransmitter have reached a higher threshold. This can lead to the fight-or-flight response – useful if we are in danger and need to be hyperalert. Unfortunately, many situations that don't involve danger, such as pressure at

work, can also put the locus coeruleus into its top gear. We may then feel overwhelmed when what we need is greater focus.

In people with anxiety or post-traumatic stress disorder, the locus coeruleus may become [too easily locked into the high-arousal mode](#) of Gear 3. "We know that there is increasing release of norepinephrine, both in wakefulness and sleep, in patients suffering from PTSD," says Sara.

### [ADHD: What's behind the recent explosion in diagnoses?](#)

Intriguingly, this gearing mechanism has also been [implicated in ADHD](#). The problem here seems to be that moving too rapidly between gears makes it hard to remain engaged on a task. Existing ADHD medications may work in part by addressing this imbalance. For instance, we know that [Ritalin raises the levels of dopamine, a neurotransmitter associated with the brain's reward system](#). This could increase the sense of reward associated with tasks and, therefore, the attention paid to them.

But Ritalin also keeps the brain's noradrenaline at a more constant level, which could then moderate the activity of the locus coeruleus through a feedback loop. "[The structure] is exquisitely sensitive to the amount of free noradrenaline and, like a thermostat, turns down its firing rate if local noradrenaline concentrations get too high," says Shine. [A](#)

[recent study](#) found that people with ADHD taking Ritalin showed patterns of eye dilation – which indicate, of course, locus coeruleus activation – similar to people without ADHD.

Given these findings, many neuroscientists now consider moderate locus coeruleus activity – that is, Gear 2 – to be key to optimum cognitive performance, a sweet spot between dreamy and frantic. “It’s when the prefrontal cortex is completely engaged and working at its best,” says Storoni.

...working on moderately difficult tasks can push the locus coeruleus into Gear 2, which enhances focused and flexible thinking...

Heiner Heine/imageBROKER.com GmbH & Co. KG/Alamy

Further [evidence supports this view](#). In 2016, for instance, scientists at Leiden University in the Netherlands tested the

attention of participants with a series of quickly morphing images showing either cities or mountains. The volunteers had to press the space bar when they saw the urban landscapes and release it when they saw the rocky summits. As they performed the task, an eye-tracking machine measured their pupil dilation. Sure enough, the most accurate performance occurred when the [pupils indicated the moderate locus coeruleus activity characteristic of Gear 2](#). Other studies indicate that [this increased concentration](#) helps us [hold more information in our short-term memory](#) – an essential ability for any complicated mental task.

Shifting to Gear 2 also seems to enhance the chance of “convergent creativity”, which entails a flash of insight or an aha! moment. Previous research has shown that giving people a tight deadline can accelerate the solution of easier puzzles, whereas the exact opposite is true for harder puzzles. The reason was once unclear, but [David Beversdorf](#) at the University of Missouri, who [analysed studies of convergent creativity](#), suggests the blue dot holds the answer. With the easier problems, he says, the extra pressure may gently raise its activity from a low baseline to its optimum point. As the task difficulty increases, however, anxiety about meeting the deadline puts the locus coeruleus into overdrive, resulting in foggier thinking. “As soon as you start worrying too much, you tip into Gear 3,” says Storoni.

# Creating a state of flow

Recent research even suggests that [Gear 2 underpins the famous "flow state"](#) – the feeling of being so totally engaged in a task that you forget the passing of time. "People find flow rewarding," says [Dimitri van der Linden](#) at Erasmus University Rotterdam in the Netherlands. "They can spend hours on the same activity." To work out whether this depends on the locus coeruleus, he and his colleagues presented people with a tricky computer game in which they had to recall a sequence of alien creatures that continued popping up on the screen while the team measured fluctuations in pupil diameter and brain activity. Sure enough, participants' feelings of [flow corresponded with activity of the locus coeruleus](#): they were more likely to endorse the statement "I was 'in the zone'" when they showed signs of sliding into Gear 2.

Flow occurs when you engage in an activity that is just challenging enough for you. So choosing the right task difficulty may be one way to change mental gears and harness the power of the locus coeruleus. Shine also points to evidence that practices like [meditation can enhance overall focus and emotional regulation](#). "I think of it as a way of training the arousal system – which the locus coeruleus is a part of – so that you have much more conscious control in everyday life," he says.

...but if we are too challenged and become stressed, the locus coeruleus slips into Gear 3, which readies us for a fight-or flight response.

Ali Balli/Anadolu Agency via Getty Images

Another strategy is to make the most of the mind-body connection. Storoni says the locus coeruleus has a direct relationship with the autonomic nervous system, which regulates things like our heart rate and breathing. This means physical movement can influence its gearing. For instance, light exercise – such as a brisk walk – in the early morning [can move us from Gear 1 to Gear 2](#). To wind down from Gear 3, meanwhile, we might [engage in yoga and controlled breathing](#).

## Tap into your circadian rhythms

In her book, Storoni suggests that we listen to our circadian rhythms, too, and plan our activities around [the natural changes in arousal](#). Those tasks that require creativity may be best suited to the start of the day, when we are easing into Gear 2 and can combine associative and analytical thinking. More focused work that involves intense information processing is better left until later in the morning, when we are firmly in Gear 2, or around 3 or 4pm, when most people return to peak focus after a mid-day dip in arousal.

We might also reconsider the way we manage our work. Monotonous or boring tasks can shift us down into Gear 1, for example, so that we lose focus and begin daydreaming. Here, the solution involves [increasing mental load](#). "Perhaps by doing something in parallel, a form of multitasking," says Storoni. [Listening to music is one option](#), but sometimes you may need something that requires more concentration, such as an audiobook. With intense work, we face the opposite problem: the brain can only spend so much time in Gear 2 [before it starts feeling fatigue](#). That's why we should arrange regular breaks.

## [How to understand your inner voice and control your inner critic](#)

[Most of us have a voice inside our heads and it can be caring, supportive, negative or critical. Learning to control this internal monologue could help you cope with daily stress](#)

In the future, new tech could increase our ability to train our locus coeruleus. Storoni points to a series of recent experiments that provided participants with real-time feedback about their pupil dilation, presented as a circle on a computer screen. Before they started the experiment, they were encouraged to think of scenes that might raise or lower their feelings of mental alertness. One participant chose to

imagine jumping from a cliff into the sea to increase their arousal, and pictured floating peacefully in the air to reduce it. The training worked: over three daily sessions, the participants had [better control over their locus coeruleus](#), a fact confirmed by a functional MRI scan that directly measured its activity.

You may have to wait a while until such equipment becomes widely available. But simply knowing about your brain's gears can make a difference. The key is self awareness: noting when your brain is under- or overstimulated and adapting your behaviour appropriately. It may have taken more than two centuries, but it is time we all learned to respect our little blue dot.

### **The laws of social connection**

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