Hit or myth?

Blamed for smartphone and gambling addiction, the ‘pleasure chemical’ has been held up by the tabloid media as the malign force behind every teenage misstep. But the research, writes Chris Parr, shows that this neurotransmitter has a positive role to play in boosting learning and memory.
Research review

Understanding the many moral panics about teenage behaviour - screen-time addiction, gaming obsession, a retreat towards face-to-face communication - satis an assumption that teens themselves are not to blame, rather they are being led astray by the manipulation of that most dastardly deceiver of free will: dopamine.

The kids can't help themselves, goes the theory, because the powers of capitalism have worked out how to use dopamine to their advantage.

There's plenty of supporting evidence. A Daily Mail headline promises to tell us 'why trendy cupcakes may be as addictive as cocaine' (it is because of dopamine, apparently). The Guardian asks, 'has dopamine got us hooked on tech?' and The Sun informs us that 'playing games [as] addictive as heroin', again citing dopamine levels in the case presented.

And who would argue against such apparently reliable claims?

Well, you should. Because not only is dopamine being given a lot more credit as a catalyst for teenage catastrophe than it deserves (or than the science supports), but the noise of all these horror stories is drowning out the good news about dopamine - news that would be particularly of interest to teachers.

So what is exactly dopamine? It's a neurotransmitter (not a hormone, as is often claimed - see box, page 18), which means it is a chemical that enables neurons to send messages between cells. There is some discussion about how many different neurotransmitters there are, but they include the likes of histamine (of allergy fame) and serotonin (the so-called 'happy' chemical). Each neurotransmitter has a few jobs to do; one of the jobs of histamine, for example, is in immune responses.

Dopamine has a number of roles, but the two that have been most studied are: the control of movement, which has gained a lot of attention because if you lose a particular subset of dopamine neurons then you can develop Parkinson's disease; and its effect on reward and motivation.

It is the latter area that has captured the imagination of academics and the public. The idea that we can be programmed to do certain things against our best interest because dopamine gives us a pleasure hit if we do it is certainly alluring: for starters, it gives us a decent excuse as to why we are playing Fortnite for five hours straight every night. But, unfortunately, it is a clear misreading of the science.

"Dopamine is not, as many still believe, involved in the pleasure or liking of an activity," explains Mac Robinson, assistant professor of psychology, neuroscience and behaviour, and integrative sciences at Wesleyan University in Connecticut.

"Instead, it is involved with wanting that outcome or reward."

In short, the bit of joy or satisfaction you get when your Instagram photo is liked is not caused by a sumptuous shot of dopamine. Instead, dopamine is involved in the desire to seek out that feeling.

Behind the curtain

Robinson describes the belief that the neurotransmitter plays a role in pleasure as "the biggest dopamine myth that the science community tries to redress."

"It is based on an erroneous interpretation of the facts from studies in the 1980s, and has since been many times disproved," he explains. "However, since the idea of a
Dopamine myth-busting

Dopamine is not a hormone
Despite sometimes being referred to as the “happy hormone”, dopamine is in fact, a neurotransmitter: one of the body’s chemicals that is responsible for transmitting signals between the nerve cells, or neurons, in the brain.

It is not simply a bringer of pleasure
Dopamine is the body’s pleasure chemical, right? Only up to a point. It is involved with the body’s reward system, and is linked to addiction in some cases. However, it serves a range of purposes relating not only to pleasure, but also to processes such as the regulation of movement and our ability to pay attention. It is also related to the expectation of pleasure, even if that expectation is never realised. Hence, it is more involved in motivating you to pursue an activity you think you will find pleasurable, rather than the actual feeling of pleasure itself.

Dopamine doesn’t make video games as addictive as Class A drugs
There is no denying that good videogame designers exploit our body’s desire for rewards incredibly effectively. Dopamine plays a big role in our reaction to a new challenge, even if it is not, strictly speaking, responsible for the feeling of pleasure derived from overcoming that channel. Video games of all types seek to offer a level of compelling challenge that will keep us coming back for more (a decision motivated by dopamine release). It is not true, however, that video-game use is associated with the same levels of dopamine release as the taking of drugs such as cocaine, or having sex. Studies show the levels are, in fact, much lower.

Dopamine, she explains, is “connected to rewarding experiences, but pleasure is a complex and interactive process that involves many different neurochemicals and hormones in your body”.

It’s important those in education recognise this, as there can often be an oversimplification of how technology can have an impact on young people: it is common to use a “pleasure reward” argument against tech to try and ban it.

Of course, this does not mean dopamine is an innocent bystander in efforts to get us hooked on our phones (or anything else, for that matter). There is no denying that good tech designers exploit our body’s desire for rewards incredibly effectively. Video games of all types, for example, seek to offer a level of compelling challenge that will keep us coming back for more (a decision influenced by dopamine release).

It is not true, however, that video-game use is associated with the same levels of dopamine release as the taking of drugs such as cocaine, or having sex, as is often claimed. Studies show the levels are, in fact, much lower. And

neurotransmitter coding for pleasure is so alluring, it has been hard to shake.”
That’s mostly because the myth keeps being peddled, says Kira Shaw, research fellow in the school of psychology at the University of Sussex.
“Dopamine is often blamed for creating addiction to things like smartphones, social media, gambling and drugs,” she says. “It is commonly claimed that dopamine is at the root of many behavioural problems. But the reality is that the picture is not actually that simple.”

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the role of dopamine in reward and motivation does not have to be a negative one. For educators, it could, in fact, be incredibly positive.

"Interestingly, less than 0.0005 per cent of the brain’s neurons produce dopamine, yet these neurons play several crucial roles in how we learn, motivate ourselves and make predictions,” says Joydeep Bhattacharya, director of research in the department of psychology at Goldsmiths, University of London.

**Learning’s pleasure principle**

The learning advantage firstly comes from the connection of dopamine to memory formation. If a pupil enjoys the lesson, then dopamine comes into play.

"Enjoyment would trigger the brain’s dopamine reward system,” says Shaw. "This system reinforces memories by strengthening neural circuits that are associated with the ‘enjoyed’ information."

Emma Cahill, a lecturer in the department of psychology, development and neuroscience at the University of Cambridge, agrees. She says that dopamine may be just one of the neurotransmitters involved in memory, but that it can be a significant player.

"Increasing dopamine can enhance information becoming encoded, or learned, and there are suggestions from animal research that it is also important for the process of remembering,” she explains. Bhattacharya adds that the "huge body of literature” showing how dopamine is critical for learning also suggests “prediction errors” are key.

"Our brain is constantly making predictions about the world, and these predictions also need to be constantly updated because we are seldom completely correct," he says. "So there is always a prediction error, and this error is central to our learning."

"When we predict something completely correctly, there is no change in the activity of the dopaminergic neurons in the brain – but if something unexpected happens, then they respond. For example, if an expected prediction fails to materialise, they quieten down, and when something happens that goes beyond expectation, they fire up.”

This leads to the hypothesis that dopamine is intricately related with coding reward prediction error, he says. "If we predict about the world perfectly, there is no need to change, so no need to learn either. Dopamine neurons code for these prediction errors, and thereby pave the way towards updating our knowledge through a process known as ‘reinforcement learning’, which is fundamental for adaptive survival in this ever-changing world."

Essentially, dopamine helps you remember new information.

Finally, dopamine can help with habit formation. “The expectation of reward helps us form habits,” Bhattacharya explains. "A good adaptive habit promotes important behaviour being performed automatically. Adaptive habits are promoted by dopamine release in the brain regions engaged with cognitive control, and with motivation and reward. Due to the dopamine conditioning, a long-term memory is likely to be formed and consolidated.”

Enjoyment, though, is obviously a highly individualistic thing. It is exceptionally difficult to translate this research into support for any particular style of teaching or approach. To add to the complexity, different people react differently to the same stimulation – and dopamine reactions can vary from person to person, too. This is particularly true for secondary-aged children.

"Adolescence is a time characterised by increased risk taking and novelty seeking,” says Shaw. "Dopamine is associated with increased appetitive behaviour, and as such, adolescence is a time of elevated activity in the dopaminergic system.”
Patrick Lewis, associate professor in the school of pharmacy at the University of Reading, adds that dopamine may be more of a determinant in behaviour the younger we are.

"The role that dopamine plays in risk, reward and motivation changes through development and may be slightly more prominent during childhood and adolescence as individuals learn the balance of risk versus reward," he says.

**Like pupil, like teacher**

What could also have an impact on the dopamine levels of the child, incidentally, are the dopamine levels of the teacher.

Dopamine plays a role in making associations that can influence motivation, which could explain why you approach that Friday afternoon double period with the uninviting class 9G with trepidation.

"If there is a class which a teacher finds rewarding and pleasurable to teach, then this will activate their dopamine reward system," says Shaw. "The dopamine rush will thus drive them to want to spend more time with this class.

"As we now also know, dopamine can similarly push someone to avoid things that they find unpleasant. As such, this system could also lead to intense dread when the teacher thinks of a class which they particularly dislike."

Lewis agrees that "dopaminergic activity will play a similar role in a teacher’s brain as it does in the student’s brain."

"It may act to reinforce experiences, both positive and negative, and modulate motivation," he says.

But he adds that "these are very complex behavioural traits, and it is important to note that dopamine is not the only neurotransmitter involved here."

"That’s an important point. While we can say that the dopamine research definitely points us in the direction of enjoyment as a key factor in teaching, and that this is likely to improve learning and memory, all this has to be heavily qualified with the fact that countless other systems are in play that add to, or subtract from, that advice."

For example, Shaw explains how introducing competition to the classroom can be a great way of using the effects of dopamine to the teacher’s advantage.

"For instance, once a topic is complete you could split students into quiz teams to answer questions on said topic, with the winning team receiving a small prize," she says.

"Doing this will foster excitement, risk-taking and urgency – all of which are linked with dopamine and learning."

But that same technique may clash with research on cognitive load if the quiz is handled badly – and if you have children who are particularly shy or who have low self-esteem, quizzes could be a nightmare and you may have the opposite effect than you were intending.

In short, teachers should know about dopamine. It will mean they avoid succumbing to simplistic notions that dopamine drives certain negative behaviours in teenagers. And they should better appreciate its positive points: if a child enjoys what they do in the class, there will likely be a benefit.

But all this has to be within the context of other knowledge about learning and the brain. This is where so much neuroscience and cognitive psychology research can be oversimplified: you cannot just pretend connected or competing things do not exist.

As Lewis says: "The brain is a fiendishly complicated organ with upwards of 80 billion neurons forming untold billions of connections and using a myriad range of chemicals to communicate cell to cell. So distilling any specific area of human activity to the action of one neurotransmitter is usually an oversimplification."

"Chris Parr is a freelance writer."