Commentary

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Stimulating Dopamine, Serotonin, Oxytocin and Endorphin by Learning How They're Stimulated in Animals

Loretta Graziano Breuning, PhD[*,1,2]

[1]*Founder, Inner Mammal Institute, USA.*

[2]*Professor Emerita, California State University, USA.*

[*]Correspondence:
Loretta Graziano Breuning, Founder of the Inner Mammal Institute, USA, E-mail: Loretta@innermammalinstitute.org.

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The human brain evolved to meet survival needs. It is constantly choosing where to invest its energy to meet those needs. When it sees a way to get a reward, it releases neurochemicals that feel good. Dopamine, serotonin, oxytocin and endorphin are stimulated by the expectation of physical and social rewards.

Expectations are neural pathways built from prior experience. These pathways are paved by neurochemicals and strengthened by repetition.

Dopamine

A hungry lion does not run after every gazelle it sees. Its brain is designed to choose wisely before investing its effort. It scans for a gazelle that it has a good chance to catch. Its dopamine surges when it sees one, which unleashes the energy a lion needs to catch its prey.

Dopamine is the feeling humans associate with scoring a touchdown or seeing the finish line in a marathon. We are always scanning for opportunities to meet our needs and releasing dopamine when we see one. Training for a marathon is fueled by dopamine when a person has neurally linked those steps to the expected reward. Each spurt of dopamine is brief, so we are constantly looking for ways to trigger more. This operating system we've inherited motivates us to meet our needs by releasing a good feeling when we approach a reward.

Oxytocin

A gazelle is in mortal danger when it strays from the herd. Returning to the group stimulates the good feeling of oxytocin. Natural selection produced a brain that rewards a mammal with oxytocin when it finds safety in mutual support. A drop in oxytocin causes a feeling of alarm, which motivates a mammal to seek out potential allies.

Oxytocin stimulates the feeling that humans call "trust." In the state of nature, trust and touch are the same thing because it is not safe to let others close enough to touch you unless you have an oxytocin pathway for them. Larger-brained mammals have more capacity to build their oxytocin pathways. Building trust bonds is a key part of their survival strategy. Oxytocin pathways build because individuals continually see how joint efforts promote their survival.

Serotonin

When two monkeys see the same banana, one of them will go for it and the other will withdraw. Conflict causes pain in the animal world, and monkeys are more motivated to avoid the teeth of a bigger troop mate than to eat the banana. Conflict is avoided except when two individuals perceive themselves as equally powerful. Serotonin rises in the monkey that seizes the one-up position. Serotonin feels good, so the mammal brain seeks opportunities to stimulate it. Serotonin is not an aggressive feeling, but a calm sense that you will get what you need. A monkey is motivated to establish dominance over a banana if it can, and then give the banana away if it's not hungry. Natural selection produced a brain that rewards you with a good feeling when you gain an advantage.

Endorphin

Endorphin evolved to help an injured animal do what it takes to survive. A gazelle can run with a lion hanging from its flesh because endorphin masks pain. A caveman with a broken leg could seek help thanks to endorphin. You have experienced endorphin if you've ever taken a bad fall and said "I'm fine," only to realize twenty minutes later that you are not fine. Your endorphin masks pain effectively because that's the job it evolved to do.

But we are not designed to inflict pain on ourselves to enjoy the endorphin. That would be a very bad survival strategy. We are designed to feel pain, after a brief respite, because it gives us the information we need to protect injuries. We can be glad we have endorphin for emergencies instead of trying to chase it.

Yet people are tempted to chase it. Runner's high is the modern world's best known endorphin release. It's important to know that runners do not enjoy it every time they run. They only get it if they run to the point of pain. Starving yourself to the point of pain can trigger it too. The tragedy is that your body adapts, so it takes more pain to release it. And soon the endorphin is metabolized and gone, so you have to distress your body again to feel it. We are designed to seek dopamine, serotonin, and oxytocin, and to save endorphin for emergencies.

The modern world has relatively few emergencies. You don't get bitten by crocodiles at the water hole. You don't get bitten by centipedes when you lay your head down at night. You can enjoy honey without suffering bee stings.

Fortunately, you get a small bit of endorphin when you move your body in new ways. Laughing triggers a bit of endorphin as it jiggles your innards. Exercise triggers a bit of it too. We can be satisfied with small endorphin rewards instead of pursuing big highs with harmful consequences.

It's Not Easy Being Mammal

Mammals promote survival by living in groups. It's not easy to live with others, and mammals evolved special brain structures that manage social behavior. The hippocampus, the hypothalamus, and other structures collectively known as the "limbic system," regulate neurochemicals that do the job. Serotonin, dopamine, and oxytocin trigger a good feeling when a mammal sees an opportunity to meet its needs. Cortisol produces a bad feeling when the mammal brain perceives a survival threat. These neurochemical messages steer a mammal toward social interactions that promote survival, and away from social interactions that pose a threat. Sometimes threat and opportunity come at the same time and behavior depends on the neural pathways built from life experience.

Mammals inherited brain structures from reptiles and added on. Reptiles avoid other reptiles except while mating. That's when the reptile brain releases a chemical equivalent of oxytocin. Mammals use oxytocin in many more ways. In childbirth, it surges in mother and child, causing bonding. A newborn's oxytocin is further stimulated by the mother's licking or stroking. If the pair gets separated accidentally, oxytocin surges when they reunite.

Touch stimulates oxytocin. When a monkey grooms another monkey's fur, both the giver and the receiver get a boost of oxytocin. When herd animals cluster, their oxytocin is stimulated. Poets and philosophers have long struggled to explain the power of love, but when you know how the mammal brain rewards behaviors that promote survival, it seems obvious.

Oxytocin prompts an organism to relax in the presence of another organism. Trust feels good, but trusting everything does not promote survival. Natural selection built a brain that makes careful decisions about when to trust and when to withhold trust. Oxytocin helps the brain learn from experience. Each time oxytocin is released; neurons active at that moment build connections. This wires the brain to seek similar experiences to trigger more of the good feeling of trust.

Even with oxytocin, group life is hard. A solitary reptile can lunge at food without considering the reaction of others. If group-living mammals did that, some would get hurt. The weaker individuals would get hurt. That's why mammals evolved a brain skilled at comparing itself to others and restraining its impulses when necessary to avoid injury.

The brain always strives to avoid injury because of the neurochemical cortisol. A big surge of cortisol causes the experiences humans call "pain." A small surge is what we cause "stress," or "anxiety"– the awareness of potential pain. Cortisol is the danger alert signal in mammals, reptiles, fish, and even invertebrates. When cortisol flows, it connects neurons, wiring a brain to recognize similar patterns in the future and start releasing the bad feeling.

The more neurons an animal has, the more it can store patterns in experience and match them to future experience to avoid potential threat. In social animals, social experiences can trigger cortisol because they're linked to physical pain. For example, losing group bonds exposes a mammal to predator risk, and the brain responds by releasing cortisol. Being bitten by a group-mate while reaching for food triggers pain, and the brain learns to avoid reaching for food in the presence of that individual. Weaker mammals thus learn to live safely alongside stronger mammals without conscious effort or intent.

Social learning gets a boost from the good feeling of serotonin as well as the bad feeling of cortisol. Serotonin is released when the brain is confident of meeting its survival needs. Serotonin has gotten attention for its anti-depressant effect in humans. Drugs like Prozac were discovered by accident without knowledge of how they work, the way aspirin was a century earlier. But much is known about serotonin in animals. This ancient neurochemical is found in mammals, reptiles, mollusks and even amoeba. A mammal has more serotonin in its digestive system than its brain. Most important, primate studies in the 1980s showed that socially dominant individuals had higher serotonin levels. Serotonin fell in alpha vervet monkeys when they lost the submission of their troop-mates. And chimpanzees dosed with serotonin soon became dominant in their troops.

These findings may be hard to reconcile with a nice person's view of how the world should work. But it all makes sense if you start with the amoeba's perspective. Serotonin surges in the one-celled animal when it detects the presence of food and the absence of danger. This triggers two important behaviors: locomotion toward the food and preparation of the digestive system to receive food. This is remarkably consistent with a dominant mammal who feels safe to lunge toward any available food. Foraging is the core survival activity that brains evolved to manage, and serotonin seems to be the brain's signal that it is safe to approach valued resources.

Serotonin promotes survival whether it is high or low. Low serotonin helps a mammal survive by avoiding conflict over resources, while high serotonin helps a mammal survive by dominating resources. This is a very brief summary of a complex phenomenon, but it helps us see how neurochemicals build the neural pathways that manage survival behavior in groups.

An animal that always deferred to others would not meet its survival needs. The brain is constantly deciding when to satisfy its needs and when to hold back to avoid harm. The neurochemical dopamine plays a key role. It triggers a good feeling when an organism sees a chance to meet its needs. Dopamine is the brain's signal that it's worth releasing the reserve tank of energy because a reward is at hand. A lion gets a surge of dopamine when it sees an isolated gazelle. An elephant gets a surge of dopamine when it sees signs of a waterhole. A monkey is fueled by dopamine when it tries again and again to crack open a nut. Your ancestors got a surge of dopamine when they saw a luscious berry patch. A promising mating opportunity also triggers dopamine in most organisms.

Dopamine acts like paving on a dirt road, building neural trails into neural superhighways. In the future, these channels turn on the dopamine as soon as the brain sees details associated with rewards in the past. This anticipation of rewards motivates a body to pursue things that triggered a good feeling before. In the state of nature, this motivates creatures to do what it takes to promote their survival.

The bigger a creature's cortex, the more it can use details from its past to find rewards and avoid pain in the future. But a big brain is not automatically a survival advantage. Neurons use so much energy that having more of them makes it harder to stay alive. A big brain only promotes survival if you really get your money's worth out of it by connecting neurons in useful ways. A reptile survives with a tiny number of neurons, and most of them are already connected at birth. Most of a reptile's survival knowledge is inherited from his ancestors, although he has a tiny capacity to build new circuits from life experience. A mammal's big cortex allows it to store information that was not available to its ancestors. A mammal uses its extra neurons to store social information, so it can respond to those around it in ways that help its survive.

A mammal with a small cortex, such as a bovine, has a small ability to store social information. A young bovine learns to distinguish its mother from other herd-mates, and herd-mates from strangers. After puberty, it knows whether it is stronger or weaker than each individual herd-mate, and how to act accordingly. A primate has a lot more neurons, so it can keep building new circuits based on new interactions with group-mates. A primate promotes survival by acting on new information about the relative strengths and weaknesses of other individuals.

Learning from experience is not always a good survival strategy. If you have to be bitten by a predator before you learn to fear predators, you might not survive. If you have to get ostracized from your group before you learn appropriate social behavior, you may not live to pass on your genes. Instead of waiting for direct experience, mammals evolved a way to learn by watching others. The mammal brain has specialized neurons, called mirror neurons, which fire when the behavior of others is observed. When a young mammal experiences its mother's fear or trust, its mirror neurons fire and start building circuits in the young mind. When a young mammal watches group-mates meet their survival needs, it learns to do the same.

Knowledge of mirror neurons is still in its infancy, but it's clear that mammals with a larger cortex have a longer childhood. It takes a long time to connect neurons in ways that promote survival. But this mammalian survival strategy works. Animals with more neurons have a longer life expectancy and a higher survival rate in their offspring. High survival rates allow a species to have fewer offspring and invest more in each one. More parental investment means each generation can be born helpless and learn from life experience instead of being born pre-programmed with the knowledge of its ancestors.

Reptiles are born with all the survival skills they need, and they leave home as soon as they're born. Mammals are completely dependent and vulnerable at birth. Reptiles have huge numbers of offspring in order to have a few that survive, while mammals have very few offspring and struggle to ensure the survival of each one. But it's not easy having all your eggs in so few baskets. A young mammal must build the necessary circuits before it loses the protection of its elders in order to survive.

The neural network built in childhood will last for a mammal's lifetime. Though new experience can add layers of detail, early experience builds the foundational pathways. A mammal's lifetime will be shaped by the early connections that tell it how to meet its needs while avoiding harm. It's not easy to choose the best social behavior in each moment. Often, threat and opportunity come in the same moment, and a mammal must sort through conflicting survival messages. It simply allows electricity to flow through the neural pathways it has already built. It's not easy living with neurochemical ups and downs, but the mammal brain has successfully promoted survival for 200 million years.