NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD

Understanding Motivation: Building the Brain Architecture That Supports Learning, Health, and Community Participation

WORKING PAPER 14

Center on the Developing Child HARVARD UNIVERSITY

NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD

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The National Scientific Council on the Developing Child, housed at the Center on the Developing Child at Harvard University, is a multi-disciplinary collaboration designed to bring the science of early childhood and early brain development to bear on public decision-making. Established in 2003, the Council is committed to an evidence-based approach to building broad-based public will that transcends political partisanship and recognizes the complementary responsibilities of family, community, workplace, and government to promote the well-being of all young children.

For more information, go to www.developingchild.net.

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The Issue

A healthy, engaged community depends on people achieving to the best of their potential, contributing actively to the economy and public well-being, and helping the next generation to thrive. A complex set of intertwined social and biological factors influences people's motivation to participate actively and productively in schools, jobs, and communities—and to persevere in the face of setbacks. To unlock this puzzle and ensure that all people have the opportunity to develop motivation to learn, improve skills, and make healthy choices, it would be helpful to understand the underlying mechanisms in the brain that develop in childhood and build the foundation for later complex behavior (see page 7 for more information).

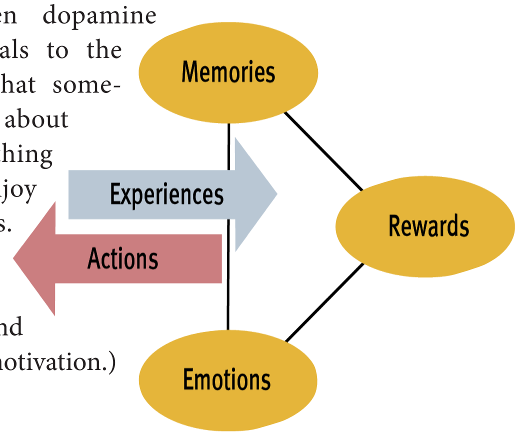
The brain circuits underlying motivation are critical for attention, learning, and decision-making. When these circuits have either not developed in a balanced and healthy way or have been chemically hijacked by addictions, challenging life circumstances can overpower the best of intentions. Programs intended to support parents and children facing adversity often find that participation is one of their greatest challenges. Dropping out of school and not participating in family support, job training, or addiction programs—all of these are reflections of motivation systems that have been disrupted by threat or hardship. Substantial scientific knowledge can inform the search for solutions by helping us understand what leads to these behaviors.

The brain systems that govern motivation are built over time, starting in the earliest years of development. These intricate neural circuits and structures are shaped by interactions between the experiences we have and the genes we are born with, which together influence both how our motivation systems develop and how they function later in life. Providing children with the kinds of early life experiences that support the development of healthy, balanced motivation systems is key to ensuring positive outcomes later—for school, work, health, and raising the next generation.

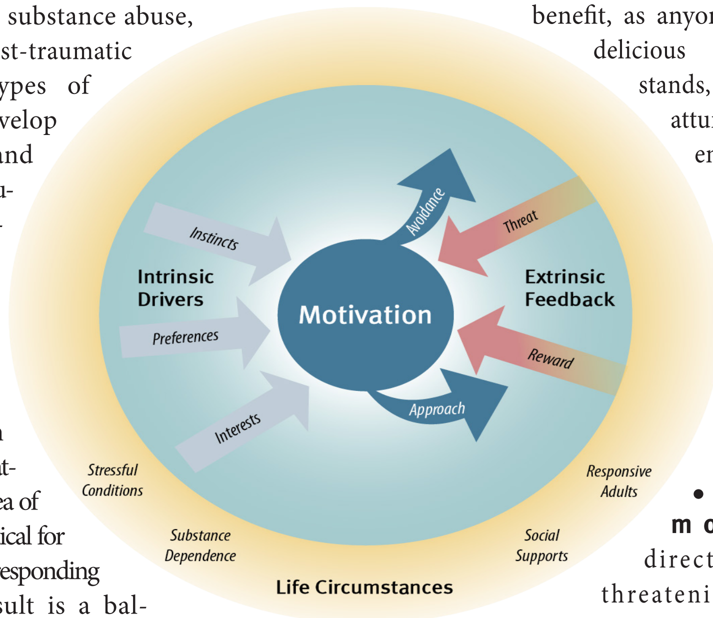
The Science of Motivation

In the brain, motivation is the result of neurons (brain cells) in specific regions sending chemical signals via high-speed neural networks to other regions, creating pathways for future signals to follow. Experiences trigger the release of these chemicals to regions that connect emotions, memory, and the sensation of pleasure or reward. This links the feeling of reward to the emotions we felt and the experience that led to it—and that influences both our *expectations* of reward and the *actions* we are motivated to take in order to get it. Given the appeal of anticipating an immediate reward, it takes strong self-regulation to resist these powerful memories and cues in favor of a long-term reward.

The chemicals, which include dopamine, serotonin, norepinephrine, glutamate,[1-2] and naturally occurring opioids that are produced in the brain, each serve different purposes. For example, when dopamine is released, it signals to the rest of the brain that something important is about to happen—something that we should enjoy or avoid at all costs. (See page 7 for more information on the brain chemicals and regions involved in motivation.)



There are two types of motivation: one directed toward expected rewards (known as approach motivation) and another directed away from threat (known as avoidance motivation). In other words, we can be motivated either to seek pleasure or to avoid danger. Both kinds of motivation are necessary for survival, and supportive developmental processes create a healthy balance between the two. When they are out of balance, *excessive* reward-seeking or danger-avoidance can lead to a range of disorders, including attention-deficit/hyperactivity, depression, substance abuse, anxiety, and post-traumatic stress.[3-6] Both types of motivation develop in childhood and are strongly influenced by what's happening in a child's environment.[7] For example, the consistent presence of a supportive adult in a child's life can calm an overactivated amygdala, an area of the brain that is critical for learning fear and responding to threat. The result is a balanced system that assesses and responds to real threats appropriately. On the other hand, children who are raised in abusive, chaotic, or scary environments without supportive adults tend to be *more* likely to perceive experiences as threatening—and respond to them as threats—but *less* likely to expect rewards when they do something positive.[8] Here, the systems become overly attuned to impulsive self-protection and less to long-term goal achievement.



- **Approach motivation** is key to most forms of learning. Anticipating a reward—which can be any experience that causes pleasure, from the taste of a delicious food to the satisfaction of achieving a goal or the glow of an act of kindness—triggers a dopamine surge. That surge is a signal to expect new experiences that are worth seeking out and learning from. The surge also increases communication between the brain region responsible for dopamine release and the regions responsible for emotion and memory. As a result, our memories of the learning experience become linked with the reward received and the emotions we felt.[9-11] Strong emotional connections to memories help us retrieve them more readily. The decisions made in order to receive a short-term reward may not always achieve a long-term benefit, as anyone tempted by a delicious dessert understands, but the brain is attuned to experiences that have previously led to a reward, and it learns to predict which experiences are likely to trigger the reward again.

- **Avoidance motivation** directs us *away* from threatening or unpleasant experiences. Avoidance motivation—which we associate with the emotions of fear or disgust—often involves activation of the amygdala.[12] When the amygdala is activated in response to threat, norepinephrine and other stress hormones are released, triggering what is often called the "fight or flight" response: increases in heart rate, blood glucose levels, and oxygen intake to the brain, and a temporary shutdown of less mission-critical functions, such as the digestive or metabolic systems. This response may be triggered by an instinctual detection and response to threat or by the conscious awareness of a potential threat (physical or emotional). Disgust protects us from ingesting or touching repulsive and often unhealthy substances. Fear and disgust—both the result of avoidance motivation—develop in the brain even *before* language: Babies feel afraid well before they can say that the feeling is fear, and are able to express disgust as early as the first day of life.[13] Avoidance motivation can also be learned through experience—when the brain correctly or incorrectly predicts how serious a particular threat may be, it learns whether (and how much) to avoid it in the future. But while important for survival, the avoidance response can actually inhibit higher-level learning by focusing the brain's activity on immediate response rather than planning to attain a long-range goal or resisting an impulsive behavior.

Both approach and avoidance motivation are influenced by intrinsic (internal) drivers and extrinsic (external) feedback. While all organisms have the intrinsic drive to survive, approach reward, and avoid threat, we may also be motivated by the inherent pleasure and satisfaction derived from an activity. Although neuroscientific understanding of intrinsic motivation is still quite recent, it is believed that intrinsically motivating experiences trigger a dopamine surge, signaling the anticipation of pleasure.[14] Once their basic needs are met, young children are motivated intrinsically by exploration, active involvement in play, and achieving mastery or success in a task, whether banging a spoon to make a noise or solving a problem. This kind of motivation is important for learning and development because it leads to intense engagement in a task and mastery is associated with pride and satisfaction.[15]

Intrinsic drivers are considered to be the strongest and most lasting motivators, especially in early childhood, but positive feedback can support and reinforce the inherent feelings of satisfaction or pleasure. For example, satisfaction from mastery is supported by positive feedback from an authority figure. But while positive feedback is important in boosting a child's self-confidence, in some cases, external rewards have been shown to undermine intrinsic drivers. That is, children are less likely to engage spontaneously in activities after they have received a tangible reward for having performed them.[16] When traditional school systems rely heavily on extrinsic feedback, such as grades and awards, this can lead to a shift from the intrinsic drive to learn to a desire for external recognition and accolades or avoidance of failure or punishment. While extrinsic motivation may be effective for some in the short term, it is unlikely to last.

Once their basic needs are met, young children are motivated intrinsically by exploration, active involvement in play, and achieving mastery or success in a task.

The combination of intrinsic drivers supported by positive extrinsic feedback is best for building a healthy motivation system, but extrinsic feedback by itself is not an effective driver of behavior over the long term.[17]

In approach motivation, there is a "wanting" system and a "liking" system, which can separate the desire to have an experience from the reward that is actually experienced. Most people are not directly aware of the underlying processes of wanting or liking—that is, it is possible to want something at a deep, physiological level without being conscious of the pleasure it elicits.

The intense desire for experiencing pleasure, or "wanting," is generated in the brain by the dopamine network, which connects the regions of the brain that trigger automatic, "non-thinking" responses to those that manage memories, emotions, and behaviors.[18] The circuits that connect the reward, the action that led to it, and the emotions felt at the time are so strong that even when the reward is withheld or diminished, the brain will still prompt us to repeat the action that initially led to the reward. That can produce "wanting" (the desire for the experience) without "liking" (the actual pleasure or reward that is felt). This separation explains why some people engage in once-rewarding behaviors past the point where they are enjoyable, like eating too much dessert or drinking too much alcohol.

The "liking" system, on the other hand, is highly localized within a small region of the brain. When naturally occurring opioids, endocannabinoids, and serotonin are transmitted, they must be received by this region to activate the actual feeling of pleasure rather than the craving for it. The liking system, therefore, consists of narrower, more fragile circuits than the wanting system, and thus is less easily activated.[19] The fragililty of these circuits may be one reason why intense pleasure is harder to experience than intense desire.[7] For example, the smell of a candy store may trigger "wanting" based on past memories linking sweets to pleasure. But the actual experience of eating the candy—or of eating too much—may not be nearly as pleasurable as the memory.

Typically, the pleasure received during *liking* triggers *wanting*, but people dealing with addiction often *want* substances or experiences intensely even when pleasure is no longer obtained from them. That's because repeated exposure to many addictive drugs causes the *wanting* systems to activate more easily and strongly. At the same time, overstimulation of the *liking* system (through, for example, artificial opioids and opiates) can lead to the need for increasing amounts of the drug to achieve the same effect. Therefore, *wanting* the drug increases even while the *liking* for a given dose may fade.[20-21] (See page 7 for more information.)

Wanting System	Liking System
Widespread, robust network across multiple regions of the brain	Highly localized within a small region of the brain
Activated through connections involving the reward, the action that led to it, and the emotions felt at the time	Activated when dopamine, serotonin, and naturally occurring opioids are received in this specific brain region
Even when a reward is diminished or absent, the brain will still prompt "wanting"	The dopamine system triggers less neural activity over time, leading to reduced pleasure from the same experiences

How Motivation Systems Develop

The brain's motivation systems are particularly sensitive during certain periods of early childhood development, when infants and young children are learning approach, avoidance, and attachment behaviors. While genes provide the basic blueprint for the motivation circuits, disruptions in developmentally appropriate experiences during these sensitive periods can affect how the circuits develop and the behaviors they shape. For example, a child can become more highly attuned to avoidance than approach, which would reduce motivation to try new activities. Because the timing of the development of motivation systems is so important, different kinds of experiences may have different impacts at different stages—the influence of peers, for example, is much stronger in adolescence than in early childhood.

Especially in the early years of life, adults caring for a child strongly influence the development of the brain and motivation system. Infants learn best through interactions with parents and other important adult caregivers who establish responsive, supportive relationships with them. The brain is biologically prepared to form strong, lasting emotional connections to these caregivers, a bond known as attachment.

Research shows that there are different sensitive periods in which attachment figures affect motivation early in life. In the earliest period, babies learn simple preferences among pleasant and unpleasant experiences.

Then they begin to distinguish between threats that truly need to be avoided and those that are less dangerous—here, the supportive presence of a trusted adult can have a buffering effect.[22] For example, a loud noise may startle a child, but if children are in the presence of someone they are attached to and feel secure with, and who responds supportively, they will be less likely to experience high levels of stress. Without these relationships—or in situations where these primary relationships are themselves a frequent source of fear—an imbalance may develop between approach and avoidance responses.

During adolescence, the motivation system is increasingly influenced by peers, exploration, and performance feedback. Adolescence represents a period of adjustment to increased independence; it is also a time of social reorientation from the influence of parents to peers. During this time, relationships with peers become more complex and intimate. They require greater social understanding and become more rewarding. Adolescence is also a time of neural and behavioral flexibility and change. Because different regions of the brain mature at different rates, during adolescence, the neural circuits involved in cognitive, emotional, and social information processing are at different stages of development and reorganization, and have not yet achieved their adult balance. Typically, adolescents show stronger neural responses to social acceptance and rejection than adults. This may explain why youth seem especially sensitive to negative social feedback, and why positive social feedback and acceptance are so rewarding.

Social interaction induces an increase in natural opioids and activates the region of the brain responsible for releasing dopamine and serotonin.[23-24] The pleasure of social acceptance is present early in life and remains important in adulthood, but is especially powerful in adolescence when the brain is particularly tuned into these rewards. The anterior cingulate cortex (ACC), a portion of the brain that monitors and appraises social acceptance and exclusion, plays a key role in reward-based decision-making and learning.

> **Because the timing of the development of motivation systems is so important, different kinds of experiences may have different impacts at different stages.**

Researchers have found that children who were chronically rejected, or had been emotionally abused or neglected, had a more active ACC and showed heightened sensitivity to the neurotransmitters released as a result of social exclusion.[25] So, while all adolescents are strongly motivated by social feedback, those who have experienced emotional abuse or rejection are even more motivated by it.[26]

The cognitive and emotional development and increased cognitive flexibility that occurs during adolescence creates both opportunities and challenges. The increased sensitivity to social rewards can lead to an inclination toward risk-taking and self-oriented acts, but also powers exploratory learning and the ability to adapt to different social contexts and cultures. Adolescents learn both by personal exploration and external feedback on their performance. For example, positive feedback can increase motivation by signaling to an adolescent that a goal is of high value and attainable. If the youth has low commitment to the goal, positive feedback can reinforce the feeling that he or she is on the right track. When someone is strongly committed to the goal already, critical feedback may be effective because it points out the discrepancy between where the youth currently is and where he or she wants to be.[27] For example, an athlete who is intrinsically driven to participate in a particular sport may be motivated to improve on weaknesses by a coach's constructive criticism, but a student who is less drawn to the sport may be motivated more by encouragement—and might disengage as a result of criticism.

How Motivation and Reward Systems Can Be Disrupted

Excessive stress and a lack of positive relationships can derail the development of well-balanced motivation systems. Children who experience a safe, supportive, and predictable environment develop healthy motivation systems that are driven by a balance of approach and avoidance, and of wanting and liking. Children whose environment is chaotic and stressful, however, may develop motivation systems that are driven by avoidance and focused on fear. Environmental factors can actually change the mapping of the nucleus accumbens, a key region of the brain that receives dopamine. In animal studies, stressful environments resulted in this region expanding its fear-generating zone, while shrinking the zone that generates desire. Conversely, calm, quiet environments *expanded* desire-generation and *reduced* fear-generation.[28]

Children whose environment is chaotic and stressful may develop motivation systems that are driven by avoidance and focused on fear.

Research has also shown that, when the stress response is activated repeatedly, the brain adapts by identifying threats more frequently and reacting to them more strongly—even if the sources of stress do not increase in severity. Over time, that increasingly stronger stress reaction may reshape circuits in the hippocampus, which controls memory, or the amygdala, which is involved in emotional reactions.

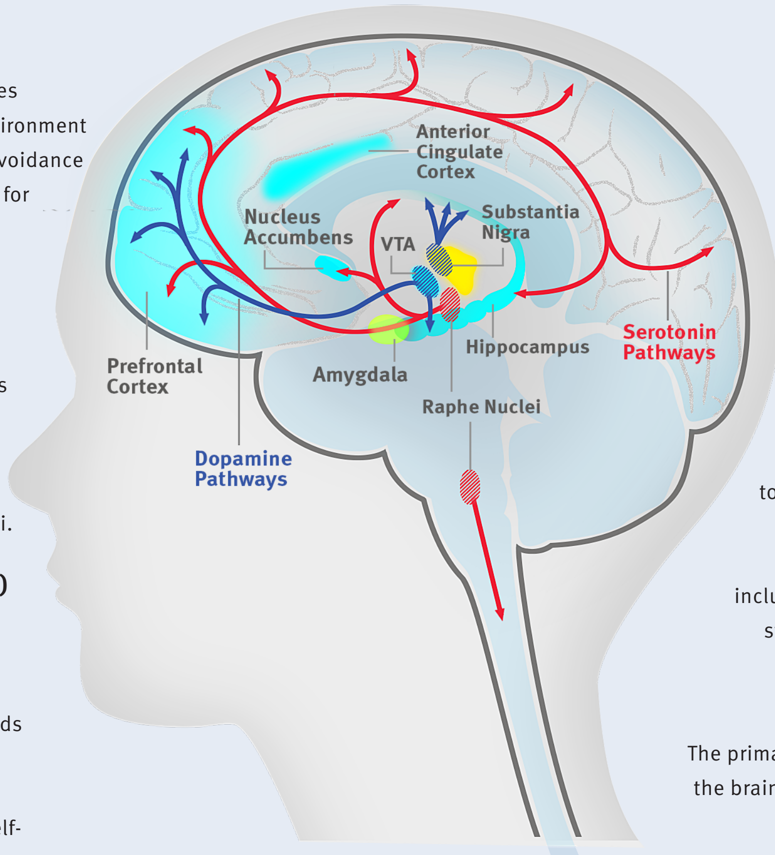
While a responsive, consistent relationship with an adult can suppress the release of stress hormones in an infant's brain, the reverse is also true. Studies find that children can over-learn fear from the adults around them, which affects the amygdala and may have long-term consequences for a child's health, learning, and social relationships.[23] Expressing fear is not always a bad thing: for example, an urgent warning from a mother when her child is moving a finger toward an electrical socket will help the child learn to avoid the socket. But excessive or misdirected fear by a primary caregiver can lead a child to lose interest in healthy exploration when the motivation to avoid threat overpowers the motivation to approach new experiences.

Feeling helpless and believing that abilities are fixed and unchangeable can disrupt the brain's motivational systems. The motivation to act also requires some expectation of success.[29] Indeed, successfully making things happen is rewarding in and of itself. We can observe this even in very young infants. If a ribbon is tied to an infant's leg and the other end attached to a mobile, when the baby notices that when she kicks the mobile moves, she will kick more vigorously.[30] She may also smile and gurgle until the ribbon is untied from the mobile, and then kick vigorously and cry angrily.[31] When a child does not see any effects from her actions, it produces what is termed "learned helplessness." People who learn that they are helpless often give up even in situations in which they can be successful.[32]

Researchers are also finding that how children and adults think about skills and talents makes a big difference in whether they are motivated to keep trying. If skills and talents are thought of as fixed—something people either have or don't have—an initial failure is likely to be attributed to a lack of natural ability and, in turn, it may decrease motivation. This is called a *fixed mindset*. On the other hand, if skills and talents are seen as capacities that can be developed through practice—a *growth mindset*—then a failure signals the need to develop the skill or talent through continued effort and practice. Evidence shows that mindset interventions with adolescents can improve academic performance, particularly among low-achieving teens.[33-34]

Notably, adults sometimes inadvertently lead children to develop a fixed mindset when we praise them for being smart, or for their talent in a particular domain, as if the ability

Key Brain Regions and Chemicals for Motivation and Reward



Regions

Amygdala

"Emotion Trigger"—rapidly assesses incoming information from the environment and activates either approach or avoidance behaviors. This structure is critical for threat detection and learned fear.

Hippocampus

"Memory Center"—lays down detailed memories of events and triggers retrieval of these memories when presented with a relevant cue. This structure also is involved in regulating the duration of stress responses to environmental stimuli.

Anterior Cingulate Cortex (ACC)

"Behavior Tracker"—monitors the environment as well as one's own behavior and others' (such as social exclusion). This region sounds the alarm when behavior needs to be modified, mobilizing regions in the prefrontal cortex involved in self-regulation and decision-making.

Prefrontal Cortex

"Air Traffic Control"—manages executive functions, self-regulation, behavioral control, planning, and complex decision-making.

Nucleus Accumbens

"Reward Anticipator"—evaluates stimuli that produce wanting or liking responses. This structure also plays an important role in learning from feedback and in reward-based decision-making.

Substantia Nigra/Ventral Tegmental Area (VTA)

"Dopamine Distributors"—produce the brain chemical dopamine and deliver it to other regions of the brain that are involved in motor function and in motivating and rewarding behaviors.

Raphe Nuclei

"Serotonin Distributors"—produce the neurotransmitter serotonin and deliver it to a wide network of circuits across the brain, including structures related to motivation, reward, and threat detection.

Chemicals

Dopamine

A key factor in "wanting," dopamine modulates neural activity when a rewarding event has occurred. Increases in dopamine reinforce the behaviors that elicited the reward and lead individuals to seek out and learn from new experiences in anticipation of a positive outcome.

Serotonin

A key factor in "liking," serotonin combines with other neurochemicals to convey euphoria and has the widest distribution in the brain. Serotonin modulates a wide array of behaviors, including a major influence on emotional states, sleep cycles, eating, and other rewarding behaviors.

Glutamate

The primary, fast chemical neurotransmitter in the brain that excites and communicates with neurons across synapses.

Norepinephrine

Triggers "fight or flight" response, which increases heart rate, glucose, and oxygen intake to the brain, and temporarily shuts down less mission-critical functions. Norepinephrine works in part by activating attention systems to the most important stimuli in the environment at that moment.

Endocannabinoids

Regulate neuronal activity caused by dopamine and related behaviors and work with opioids and serotonin to produce euphoria.

Opioids

A class of naturally occurring chemicals, such as endorphins, that reduce pain and can produce euphoria. Opioids are released by the body during exercise and pleasurable activities. Use of artificial opioids, such as heroin and a number of prescription painkillers, can desensitize the reward circuitry of the brain and result in addiction that increases drug-seeking.

Illustration by Betsy Hayes

is something that they possess naturally, and not something they can develop over time. Modeling is also important and can influence a sense of self-efficacy. A study in which infants witnessed one adult working hard to achieve a specific goal and another succeeding at a goal effortlessly found that infants persisted at a novel task more after observing the high-effort example.[35-36]

Instrinsic motivation can either be encouraged or suppressed by the experiences adults provide for children.

Thus, even babies are sensitive to what they witness regarding the relationship between effort and outcome.

Addictive drugs and behaviors can hijack the brain's motivation and reward systems. The overwhelming compulsion to seek and take drugs or alcohol, or engage in a range of pleasure-stimulating activities such as gambling or casual sex, involves both positive and negative reinforcement. By flooding the nucleus accumbens with dopamine, these activities provide a short-cut to pleasure, bypassing the time and effort required to trigger similiar positive feelings of reward that are generated by achieving a goal or mastering a skill. Other parts of the brain create memories of this rapid experience of pleasure and connect them to the wanting and liking systems. By contrast, these activities may also temporarily suppress the intensity of negative emotions, leading to their use as self-medication. Stated simply, these experiences can quickly ramp up good feelings *and* tamp down bad feelings—but only temporarily. This can create a spiral of dysregulation, in which the addictive experience triggers initial pleasure, followed by negative emotions and physical craving, which can only be suppressed by the addictive behavior.[37]

Addictive drugs can often release more dopamine than natural rewards. This over-stimulation of cells that receive dopamine can, over time, change the neural pathways and chemistry in the motivation systems. As a result, the brain becomes less and less affected by dopamine, at least as long as the drug continues to be taken.[38] However, the wanting systems can become permanently *hyper*-reactive to drug cues, even after ending drug use. In other words, the repeated use of a short-cut to pleasure creates circuitry that is so strongly associated with *memories* of pleasure that the wanting system produces powerful urges to follow it, even when the pleasure itself fades. Ultimately, the mere memory of the behavior—and even the associations of people or places with the behavior—can lead to the impulsive actions that characterize addiction.[39]

Implications for Parents, Caregivers, and Teachers

The intrinsic motivation to learn about the world around us begins in infancy. This type of motivation can either be encouraged or suppressed by the experiences adults provide for children. Psychological research points to a set of promising approaches that parents and practitioners can use to promote positive motivation and learning during development.

- **Follow babies' lead.** Babies naturally orient toward novel objects and events. They look away from objects that are overly familiar, but also from new ones that are too complex. This is sometimes called the "Goldilocks effect:" things are interesting when they are novel, but not too novel.[40] When interacting with infants, notice what they pay attention to, and engage with them around their interests.

- **Elicit curiosity.** Infants seek to explore objects—especially those that behave in surprising ways. When they drop something on the floor or throw it, they're trying to see what will happen next.[41] Provide infants with opportunities to interact with new objects—and let them lead and learn!

- **Encourage children's playful exploration**. When given the opportunity, children of all ages spontaneously engage in play. The ingredients of play are precisely the ones that fuel learning: play is intrinsically motivating, it presents an opportunity for novel experiences and for learning from others, it requires active engagement, and it can strengthen social bonds and reduce stress. When life is busy or chaotic, it can be hard to find the time and space to encourage children's play, but this is an important aspect of development.[42]

- **Prioritize social interaction during learning**. In the digital age, there are many educational, computer-based applications designed for children, even as young as 6 months.[43-44] However, even the best-designed and most effective apps cannot replace real-life social interactions with adults and peers. In one study, babies learned elements of language more effectively when face-to-face with a teacher or caregiver than when watching her on video.[45] Recent research shows that young children can learn from digital media, such as touch-screen tablets, but social interaction during this learning experience appears to be essential.[46]

Five Facts About Motivation That Are Often Misunderstood

1. **Motivation comes from a set of neurochemical networks that develop over time, as a result of the experiences we have.** Despite the common misperception that some people just naturally have or lack motivation, science shows that the nature of caregiving relationships and opportunities for safe exploration that we provide young children affect the development of these systems—for better or for worse.

2. **The best way to sustain motivation is to support internal drivers with the right kind of external feedback.** Carrots (rewards) and sticks (punishments) are not the only ways to motivate people. Systems focused solely on external rewards and punishments are unlikely to achieve sustained, productive motivation; those that balance intrinsically motivating activities—such as creative problem-solving and playful learning—with positive feedback are more likely to support healthy motivation over the long run.

3. **Addictions divert motivation systems and require more than willpower to overcome.** Addictions chemically hijack the basic biological systems that have evolved for optimal survival. Addiction does not reflect a simple lack of conscious effort or a "failure of character;" managing addictions requires blocking these chemical diversions below the conscious level.

4. **Motivation is complicated and has many influences.** Behavior is affected by the experiences and conditions that shape a mindset that goal achievement is possible—and, critically, by having the resources, time, skills, and supports that make successful action feasible. It is incorrect to say that if anyone wants something badly enough, he or she will find a way to do it.

5. **Providing a predictable reward is not enough to sustain motivation over time.** Experiences that are exactly as expected every time lose their novelty, and eventually elicit less neural activity in the dopamine system. When we experience a reward that is better than predicted, the brain will prefer that experience in the future; if the reward is less than expected, the brain will ultimately exhibit less motivation toward that experience. So "keeping things fresh," whether through new activities, different locations, or a different reward, is good advice for sustaining motivation.[14]

- **Challenge children just enough.** Kids are motivated to work toward achievable goals. From infancy onward, effort is required to sustain motivation, but success must be possible. They lose motivation when a task is too easy, but also when it is so difficult as to be insurmountable. Video games harness this basic principle of learning effectively, constantly increasing the level of challenge based on an individual child's performance. Try to adapt a challenge according to a child's current capabilities, and provide prompt feedback on his or her performance.

- **Give children agency**. Children are more motivated when they have some degree of self-determination, and can elect to pursue tasks that are personally meaningful. When they have a choice of projects, or at least a little wiggle room as to how a task gets done, children are more likely to stay engaged.[15]

- **Provide incentives only when necessary**. When children are suddenly rewarded for something they enjoy and do freely, they may begin to do it only when they know they will be compensated afterwards.[47] Wherever possible, harness children's natural curiosity and inclination to work toward an achievable goal, rather than promising a reward.

- **Praise the process rather than the outcome.**[47] When we praise children for their intellect or skill level—or the grade or gold medal they received—it can lead to a performance orientation. They may be motivated to achieve more rewards, but they may also learn to shy away from challenging activities that they might not excel at, for fear of negative evaluation. Performance pressure increases as children move up in school, and it is associated with depression and anxiety in addition to diminished joy of learning. When we praise children for their effort and help them see falling short as an opportunity to learn and improve (rather than simply focus on the outcome), they will be more motivated to work hard and more likely to believe that they can achieve what they put their mind to.

- **Maintain a close connection with adolescents.** Adolescence is a period when many young people take risks and push boundaries. This trend reflects, in large part, a natural inclination toward novel and exciting experiences that maximize learning opportunities and are important in making the transition to independence. As teens become more motivated by the approval of their peers, it can be socially rewarding to follow risk-taking leaders or stand out by breaking boundaries. However, teens with close family relationships are less prone to risk-taking.[48] High parental support and open dialogue are associated with fewer problem behaviors, including less substance abuse and delinquency. Be empathetic and supportive, knowing that youth are going through changes in their brains, bodies, and social relations that can make risky behavior appealing to them. Keep the lines of communication open—and keep close tabs on teens.

Implications for Policy and Public Systems

- **Support the development of motivation in early childhood programs.** Knowing that the brain systems underlying motivation begin to develop in infancy, we can help children develop the balanced systems they will need later in life by starting in the earliest years. High teacher-to-child ratios, training in effective strategies to facilitate playful exploration and build self-efficacy, reducing stress in families' lives, and skill-building for parents and providers of early care and education are all contributors to ensuring that the foundations of healthy motivation systems are built in early childhood.

- **Shift schools toward a balance of positive feedback that supports intrinsic drivers.** To improve student motivation, school systems should reduce emphasis on extrinsic rewards (like grades, tests, and performance-based recognition programs) and increase emphasis on constructive feedback and coaching to improve performance. Support and reward exploration, praise effort, and use successes in one area to inspire effort in another, while avoiding punishment-based approaches.

- **Focus response to addiction on treatment rather than punishment.** Policies and programs relating to addictions can be improved by understanding that addictive drugs rewire and redirect motivation and reward systems. Knowing that craving or wanting addictive substances happens below the conscious level means that solutions must also occur on the physiological or biological level, rather than expecting awareness of potential punishments to change behavior.

- **Include motivation-building supports in programs for adults who care for young children.** Foster a growth mindset by praising effort, looking at mistakes as learning opportunities, and monitoring progress toward goals. Incorporate and test promising methods for goal-setting and keeping people on track to achieve self-defined goals. These approaches can not only improve retention in programs, but can also enable parents and caregivers to model and support these skills and mindsets in children.

- **Replace punitive approaches to program retention with methods that reduce stress, provide positive feedback and social/peer support, and demonstrate quick successes.** Many programs designed to help families with young children struggle to engage parents to participate actively and stay with the program long enough to truly benefit. Many factors contribute to program engagement and retention, ranging from inconvenience of timing, location, and transportation, to cost, child care needs, and competition with other activities or the needs of other family members and friends. Along with addressing those factors, programs can increase motivation to participate by making it easier to rejoin after a lapse (reducing stress), helping participants achieve small successes quickly (building self-efficacy), and making participation more rewarding by praising effort (strengthening a growth mindset).

References

1. Powledge, T.M. (1999). Addiction and the brain: The dopamine pathway is helping researchers find their way through the addiction maze. *BioScience*, *49*(7), 513-19.
2. Tzschentke, T.M. & Schmidt, W.J. (2003). Glutamatergic mechanisms in addiction. *Molecular Psychiatry*, *8*(4), 73-82.
3. Meyer, B., Johnson, S.L., & Carver, C.S. (1999). Exploring behavioral activation and inhibition sensitivities among college students at risk for bipolar spectrum symptomatology. *Journal of Psychopathology and Behavioral Assessment*, *21*(4), 275-92.
4. Muris, P., Merckelbach, H., Schmidt, H., & et al. (2001). Anxiety and depression as correlates of self-reported behavioural inhibition in normal adolescents. *Behaviour Research Therapy*, *39*(9), 1051-61.
5. Kasch, K.L., Rottenberg, J., Arnow, B.A., & et al. (2002). Behavioral activation and inhibition systems and the severity and course of depression. *Journal of Abnormal Psychology*, *111*(4), 589-97.
6. Nelson-Gray, R.O., Keane, S.P., Hurst, R.M., & et al. (2006). A modified DBT skills training program for oppositional defiant adolescents: Promising preliminary findings. *Behaviour Research and Therapy*, *44*(12), 1811-20.
7. Berridge, K.C. & Kringelbach, M.L. (2013). Neuroscience of affect: Brain mechanisms of pleasure and displeasure. *Current Opinion in Neurobiology, 23*(3), 294-303.
8. Berridge, K.C. & O'Doherty, J.P. (2014). From experienced utility to decision utility. In Glimcher P.W., & Fehr, E. (Eds.) *Neuroeconomics: Decision making and the brain*. (San Diego: Academic Press), 335-51.
9. Adcock, R.A., Thangavel, A., Whitfield-Gabrieli, S., & et al. (2006). Reward-motivated learning: Mesolimbic activation precedes memory formation. *Neuron*, *50*(3), 507-17.
10. Murty, V.P., Ballard I.C., Macduffie K.E., & et al. (2013). Hippocampal networks habituate as novelty accumulates. *Learning & Memory*, *20*(4), 229-35.
11. Murty, V.P., Labar, K.S., & Adcock, R.A. (2012). Threat of punishment motivates memory encoding via amygdala, not midbrain, interactions with the medial temporal lobe. *Journal of Neuroscience*, *32*(26), 8969-76.
12. Shabel, S.J., Schairer, W., Donahue R.J., & et al. (2011). Similar neural activity during fear and disgust in the rat basolateral amygdala. *PLoS One*, *6*(2), 317-25.
13. Graillon, A., Barr, R.G., Young, S.N., & et al. (1997). Differential response to intraoral sucrose, quinine and corn oil in crying human newborns. *Physiol Behav., 62*(2), 317-25.
14. Di Domenico, S.I. & Ryan, R.M. (2017). The emerging neuroscience of intrinsic motivation: A new frontier in self-determination research. *Frontiers in Human Neuroscience*, *11*, 145.
15. Stipek, D. (2011). Classroom practices and children's motivation to learn. In Ziegler, E., Gilliam, W.S., & Barnett, W.S. (Eds.) *The pre-K debates: Current controversies and issues*. (Baltimore, MD: Brookes Publishing), 98-103.
16. Deci, E.L., Koestner, R., & Ryan, R.M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*(6), 627-68.
17. Stipek, D. (2011). Education is not a race. *Science, 332*(6037), 1481.
18. Berridge, K.C., Robinson, T.E., & Aldridge, J.W. (2009). Dissecting components of reward: 'Liking', 'wanting', and learning. *Current Opinion in Pharmacology*, *9*(1), 65-73.
19. Peciña, S. (2008). Opioid reward 'liking' and 'wanting' in the nucleus accumbens. *Physiology & Behavior, 94*(5), 675-80.
20. Berridge, K.C. & Robinson T.E. (1995). The mind of an addicted brain: Neural sensitization of wanting verus liking. *Current Directions in Psychological Science, 4*(3), 71-5.
21. Galanter, M., Kleber, H.D., & Brady, K.T. (Eds.). (2015). Neurobiology of Opiates and Opioids. In *The American Psychiatric Publishing Textbook of Substance Abuse Treatment, Fifth Edition*. (Arlington, VA: American Psychiatric Publishing), 277-95.
22. Moriceau, S. & Sullivan, R.M. (2006). Maternal presence serves as a switch between learning fear and attraction in infancy. *Nature Neuroscience*, *9*(8), 1004-6.
23. Lahvis, G.P. (2016). Social reward and empathy as proximal contributions to altruism: The camaraderie effect. In Wöhr M., Krach S. (Eds.) *Social Behavior from Rodents to Humans. Neural Foundations and Clinical Implications*. (Cham, Switzerland: Springer International Publishing Group), 127-57.
24. Krach, S., Paulus, F.M., Bodden, M., & et al. (2010). The rewarding nature of social interactions. *Frontiers in Behavioral Neuroscience*, *4,* 22.
25. van Harmelen, A.L., Hauber, K., Gunther Moor, B., & et al. (2014). Childhood emotional maltreatment severity is associated with dorsal medial prefrontal cortex responsivity to social exclusion in young adults. *PLoS One*, *9*(1), e85107.
26. Crone, E.A. & Dahl, R.E. (2012). Understanding adolescence as a period of social-affective engagement and goal flexibility. *Nature Reviews Neuroscience*, *13*(9), 636-50.
27. Fishbach, A., Eyal, T., & Finkelstein S.R. (2010). How positive and negative feedback motivate goal pursuit. *Social and Personality Psychology Compass*, *4*(8), 517-30.
28. Braver, T.S., Krug, M.K., Chiew K.S., & et al. (2014). Mechanisms of motivation-cognition interaction: Challenges and opportunities. *Cognitive, Affective, & Behavioral Neuroscience*, *14*(2), 443-72.
29. Duckworth, A. & Gross, J.J. (2014). Self-control and grit: Related but separable determinants of success. *Current Directions in Psychological Science*, *23*(5), 319-25.
30. Rovee-Collier, C.K. & Gekoski, M.J. (1979). The economics of infancy: A review of conjugate reinforcement. *Advances in Child Development and Behavior*, *13*, 195-255.
31. Lewis, M. & Ramsay, D. (2005). Infant emotional and cortisol responses to goal blockage. *Child Development*, *76*(2), 518-30.
32. Seligman, M.E. (1972). Learned helplessness. *Annual Review of Medicine*, *23*, 407-12.
33. Gunderson, E.A., Gripshover, S.J., Romero, C., & et al. (2013). Parent praise to 1- to 3-year-olds predicts children's motivational frameworks 5 years later. *Child Development*, *84*(5), 1526-41.
34. Mueller, C.M. & Dweck, C.S. (1998) Praise for intelligence can undermind children's motivation and performance. *Journal of Personality and Social Psychology*, *75*(1), 33-52.
35. Leonard, J.A., Lee, Y., & Schulz, L.E. (2017). Infants make more attempts to achieve a goal when they see adults persist. *Science*, *357*(6357), 1290-4.
36. Cook, D.A. & Artino, A.R. (2016). Motivation to learn: An

overview of contemporary theroies. *Medical Education*, *50*(10), 997-1014.

37. Edwards, S. & Koob, G.F. (2010). Neurobiology of dysregulated motivational systems in drug addiction. *Future Neurobiology*, *5*(3), 393-401.
38. Harvard Health Publishing (2011). How addiction hijacks the brain. *Harvard Mental Health Letter*. Retrieved from: https://www.health.harvard.edu/newsletter_article/how-addiction-hijacks-the-brain.
39. Volkow, N.D., Wang, G.J., Fowler, J.S., & et al. (2010). Addiction: Decreased reward sensitivity and increased expectation sensitivity conspire to overwhelm the brain's control circuit. *BioEssays*, *32*(9), 748-55.
40. Kidd, C. & Hayden, B.Y. (2015). The psychology and neuroscience of curiosity. *Neuron*, *88*(3), 449-60.
41. Stahl, A.E. & Feigenson, L. (2015). Observing the unexpected enhances infants' learning and exploration. *Science*, *348*(6230), 91-4.
42. Milteer, R.M., Ginsburg, K.R., & et al. (2012). The importance of play in promoting healthy child development and maintaining strong parent-child bond: Focus on children in poverty. *Pediatrics*, *129*(1), e204-13.
43. Sifferlin, A. (2015). 6-month-old babies are now using tablets and smartphones. *Time*. Retrieved from: http://time.com/3834978/babies-use-devices/.
44. Russo-Johnson, C., Troseth G., Duncan, C., & et al. (2017). All tapped out: Touchscreen interactivity and young children's word learning. *Frontiers in Psychology*, *8*, 578.
45. Kuhl, P.K. (2004). Early language acquisition: Cracking the speech code. *Nature Reviews Neuroscience*, *5*(11), 831-43.
46. Lovato, S.B. & Waxman, S.R. (2016). Young children learning from touch screens: Taking a wider view. *Frontiers in Psychology*, *7*, 1078.
47. Grant H. & Dweck, C.S. (2003). Clarifying achievement goals and their impact. *Journal of Personality and Social Psychology*, *85*(3), 541-53.
48. Qu, Y., Fuligni, A.J., Galván, A., & et al. (2015) Buffering effect of positive parent–child relationships on adolescent risk taking: A longitudinal neuroimaging investigation. *Developmental Cognitive Neuroscience*, *15*, 26-34.

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