

## DEVELOPING A SOCIAL NEUROSCIENTIFIC UNDERSTANDING OF YOUTH BEHAVIORS: BASIC UNDERSTANDING

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### Abstract

Although we know that certain factors, such as a child's disadvantaged background, problems with family – severe physical and psychological trauma may trigger undesirable behaviors – there is not a consistent pattern of cause and effect. The new field of social neuroscience provides a blend of social and biological factors that offer a deeper understanding of root causes versus symptoms. This session provides a basic educational understanding about five key brain chemicals and how they work together to define a youth's physiological make-up and affect behaviors, moods, and performance issues. Each brain chemical will be introduced with an explanation of resulting behaviors when 'out of balance.' The impact of diet, exercise, and drugs on brain chemistry will also be presented. Relevant examples will be presented from peer-reviewed clinical research.

### Introduction

The last decade has brought exciting breakthroughs in understanding the brain with insights about neurochemistry of the brain, the brain maturation process, and how those two areas alone factor in defining behaviors, moods, and performance of youth. The link between brain chemistry and resulting behaviors begins with a basic education about the role and function of neurotransmitters (brain chemicals), and the impact of some controllable influencers such as diet, nutrition, exercise, activities, thoughts, and drugs. All of these influencers alter brain chemistry resulting in either desired or unwanted behaviors.

The maturation of the brain follows a set schedule with the prefrontal cortex, responsible for controlling impulses, aiding in decision-making, and judgment, being the last brain region to mature. The prefrontal cortex is not fully mature until around age 25. Coupling these compelling facts about the brain presents a far-reaching paradigm shift in our education and legal systems.

The next decade – if not next week, next month, or next year – will bring a closer relationship amongst psychologists, sociologists, anthropologists, and other social science disciplines with neuroscience. The focus of the linked sciences, termed social neuroscience, is to provide a holistic and systems approach to better understanding youth, development, and some causes of behaviors while distinguishing the difference between problems and symptoms.

Chemical imbalances in the brain can lead to unwanted behaviors such as violence, bullying, addictions, drug and alcohol use and abuse, performance issues, and mood problems. Brain chemistry contributes to the emotional and behavioral health of children and adolescents.

### Discussion

Though neurochemistry is complex, this basic educational introduction provides a simple explanation using the metaphor of a vehicle with each of five brain chemicals (key neurotransmitters) taking a role of either a

“brake or gas pedal” action – each neurotransmitter either arouses or calms the brain. For example, a study conducted by Grasby at Hammersmith Hospital in London found that youth actively engaged in violent video game playing experience both arousal and a craving desire to continue playing. During the game, the brain released excessively high levels of dopamine, comparable to dopamine release after being injected with amphetamines.

Social interactions affect brain health, and brain health can impact social interactions and perceptions. The following is an overview of the five key neurotransmitters to be presented: dopamine, serotonin, acetylcholine, norepinephrine, and GABA (Gamma-Aminobutyric Acid).

## 1. Dopamine

### Basic Biology of Dopamine

Dopamine is a brain chemical whose activity defines it as an excitatory neurotransmitter. Its primary function helps a child feel alert and aware, and to experience situations with a healthy measure of assertiveness and aggression. Dopamine also affects the brain’s processes that control muscle movement and ability to experience pleasure and pain.

When this brain chemical is at its optimum, the child will have an accurate perception of experiences and situations. Using the metaphor of a vehicle, this neurotransmitter (brain chemical) can be termed as a gas pedal brain chemical. Dopamine provides the brain with a sense of motivation enabling a child to feel good about performing tasks, and to have a sense of reward when partaking in activities. Dopamine is the chemical messenger that results in the feeling of reward which further encourages the child to repeat a prior behavior or task that had produced that feeling of reward.

Dopamine also produces the emotional response of pleasure, which is why this neurotransmitter is often associated with substance addictions and addictive behaviors. The feeling of reward and pleasure sets the stage for a child to continually seek those feelings. The behaviors and substances that resulted in a surge of dopamine can trigger a desire for a child to repeat the behaviors or activities in order to experience the emotional feelings of pleasure (Howard, 2006, pp. 427-429).

Thoughts can influence brain chemistry. Therefore, it is important that balanced levels of dopamine are essential for healthy perceptions of reality. Excess levels of dopamine, which stimulates alertness and awareness, can cause muscular tension, disrupted sleep patterns, and result in grandiose thinking, excessive self-confidence, and a shortened attention span. Excess dopamine has also been associated with ADHD symptoms and risk-taking behaviors, such as gambling and drug abuse. When dopamine levels are excessively elevated, the resulting behaviors can include delusions, hallucinations, and withdrawal. Low levels of dopamine can result in depression, low energy, excessive sleep, or suicide ideation.

Many school social workers state that when the counseled child is asked why they did the wrong thing, the response is they did not want to. This simple response to a troublesome behavior, at first, does not provide a satisfactory answer. Although the child’s response could have factual truth that the child did not want to do the wrong thing, s/he seemingly could not help themselves to stop. The idea of lack of willpower or morals often comes to mind, however, if the child’s brain chemistry, particularly dopamine, was out of balance. When brain chemistry is out of balance, what feels good is often what keeps it out of balance. So in this case, the child’s dopamine levels might have been mildly or very elevated. If the child’s level of dopamine was low prior to the troublesome behavior, then it might have been that the child was performing the behavior to self-stimulate the release of more dopamine. The sedentary atmosphere and pace of the classroom may be

considered boring and slow which challenges a child's brain chemistry of high dopamine. Ultimately, the child learns to repeat behaviors and activities that make them feel good.

## The Chemical Building Blocks of Dopamine

Dopamine is made from the amino acid building block L-tyrosine. L-tyrosine is richly abundant in foods that are high in protein. Some food items rich in this amino acid include meat, fish, poultry, beans, nuts, tofu, dairy, and whey protein. The marketplace offers sports drinks that are a source of high protein as well.

## Impact on Dopamine Levels

There is a multitude of factors that influence the level of dopamine. Each influencer can result in a different outcome based on the level of dopamine and other brain chemicals prior to the new influence. Some commonly known influences are stress, exercise, activities, emotions, diet and nutrition, and thoughts. Some other external influencers of dopamine are viewing violence, violent video game playing, gambling, high-risk behaviors (e.g. driving fast), and addictive substances. Understanding some basics about dopamine and the factors that can greatly influence levels and alter behaviors and moods provides the potential for making different choices. What a child eats and drinks can change the level of dopamine and have a resulting impact on the level of other neurotransmitters.

## 2. Serotonin

### The Basic Biology of Serotonin

Serotonin is a brain chemical whose activity defines it as an inhibitory neurotransmitter. Its primary function helps a child to calm their moods and aids in the child's ability to concentrate. When serotonin levels are at an optimal level the child will have a sense of well-being and that 'all is well in their world.' The child will have feelings of security and stabilized moods. When dopamine and serotonin levels are in optimal balance, the child will have an accurate perception of experiences and situations.

We may think of self-esteem, confidence, or the ability to concentrate as invisible characteristics, grounded in the equally invisible psyche, but they too have roots in biochemistry. All balanced emotional conditions and even such elevated states as happiness and joy are associated with normal or high serotonin levels. On the other hand, insecurity, anger, fear, paranoia, depression and even suicide ideation are associated with low levels of serotonin (Niehoff, 1999, pp. 135-145).

Using the metaphor of a vehicle, this neurotransmitter can be termed as a brake pedal brain chemical. Now we have serotonin acting as a brake pedal, and dopamine is acting as a gas pedal neurotransmitter. Continuing with the metaphor, the braking action can help temper the acceleration, and likewise increased acceleration, the gas pedal action, can override any braking efforts. In a simple to understand explanation: when dopamine levels elevate, dopamine has a tendency to overwhelm serotonin which results in pushing serotonin levels down.

### The Chemical Building Blocks of Serotonin

Serotonin is synthesized from the amino acid tryptophan. Tryptophan is commonly found in carbohydrates and carbohydrate-rich foods. Many animal proteins contain tryptophan but, paradoxically, serotonin levels tend to go down when proteins are eaten at the same time with tryptophan. This interesting phenomenon

happens because of the relationship between dopamine and serotonin. Simply stated, dopamine has a strong influence on serotonin.

### Impact on Serotonin Levels

Some commonly known influencers on serotonin are stress, exercise, activities, emotions, diet and nutrition, and thoughts. The impact of imbalances in serotonin, in the normal brain, can result in a range of behaviors and moods: depression, suicide, violence, impulse dyscontrol, and conduct disorder. It is important to remember that the resulting behaviors and moods of serotonin imbalances can arise from a multitude of ways. There is no simple explanation. Understanding this complex neurotransmitter is a first step in building an appreciation of its role in unwanted behaviors.

According to Royce and Coccarro (2002), impulsivity is an aspect of personality which can be divided into two major components: temperament and character. Temperament is considered to be heritable, recognizable in early life, and remaining relatively stable, and correlated with a variety of biological variables. Character is less influenced by biological factors than is temperament and is considered to be influenced by relationships with others and with society and the set of values the person applies to society. Both researchers reference the discovery in 1976 by Asberg and others who found reduced levels of serotonin in patients with depression were associated with a history of suicide attempts (Royce and Coccarro 2002).

## 3. Acetylcholine

### The Basic Biology of Acetylcholine

Acetylcholine is a unique brain chemical whose activity defines it as an inhibitory or excitatory neurotransmitter. Acetylcholine's primary function is with memory, which is essential for both the storage and recall of memories, and is partly responsible for concentration and focus. This neurotransmitter also plays a significant role in muscle movement and muscular coordination.

Acetylcholine's unusual characteristic of either activity is influenced by the level of the other four brain chemicals. Acetylcholine takes the role of an excitatory neurotransmitter when there are elevated levels of the two key excitatory neurotransmitters, dopamine and norepinephrine. When either of the excitatory neurotransmitters is elevated, acetylcholine shifts its role to an excitatory neurotransmitter which attenuates the impact of the increased level of dopamine and norepinephrine. This additive effect can exacerbate the resulting behavioral problems of elevated dopamine. Conversely, when dopamine and norepinephrine levels are optimal or lowered, acetylcholine can take an inhibitory role. This inhibitory role can help accentuate the inhibitory impact of serotonin, when serotonin levels are at an optimum.

Using the metaphor of a vehicle, this neurotransmitter can be termed as a gas pedal or a brake pedal brain chemical. Now we have a dopamine 'gas pedal' coupled with a weak serotonin 'brake pedal,' and acetylcholine that can take the role of either a 'gas or brake pedal.' So we have the potential of two 'brake or gas pedals.' When dopamine, a 'gas pedal' is attenuated by acetylcholine taking the role of a 'gas pedal,' the net result is a greatly increased presence of excitatory brain chemicals. As with a vehicle, when the gas pedal is pressed down to the floor, there will be little impact from a weak application of the brake pedal – serotonin.

Continuing with the vehicle example, there are two ways to stop a car: one way is to increase the braking, and the other is to ease back on the gas pedal acceleration. This metaphor helps in understanding the impact of one neurotransmitter upon another with the potential behavioral outcomes being different depending on the influencers that increase or decrease the level of a neurotransmitter. The interrelationships between and amongst the neurotransmitters becomes more fascinating as each of the five neurotransmitters are introduced.

## The Chemical Building Blocks of Acetylcholine

Unlike the other four key neurotransmitters, acetylcholine is not made from amino acids. Its primary building block is choline, which belongs to the vitamin B family and is a fat-like substance that is necessary to metabolize fats. Choline is found in lecithin. Foods high in lecithin include egg yolks, wheat germ, soybeans, organ meats, and whole wheat products. Vitamin C and B5 are needed for the brain to synthesize acetylcholine, in the presence of choline acetyltransferase, a key brain enzyme. Unlike the precursors of the other four neurotransmitters, choline does not have to compete for entry through the brain's filter called the blood-brain barrier. (See The Franklin Institute at <http://www.fi.edu/brain/proteins.htm>.)

Acetylcholine was the very first neurotransmitter to have been discovered and is the most common neurotransmitter, found in up to 15 percent of the body's nerve cells. Acetylcholine is also one of the central nervous system neurotransmitters whose concentration has been found to be affected directly by diet (Edelson 1988, 79).

## 4. Norepinephrine

### The Basic Biology of Norepinephrine

Norepinephrine (sometimes called noradrenaline) is a brain chemical whose activity defines it as an excitatory neurotransmitter. Its primary functions help in heightened alertness, muscle activity, the constriction and dilation of blood vessels, elevated heart rate, and the opening of bronchioles in the respiratory tract. As with other neurotransmitters, norepinephrine regulates emotional behaviors and moods and is influenced when levels increase or decrease. At optimal levels, it helps the child to feel energized and alert. Norepinephrine also aids in preparing the child for the fight-or-flight response (Edelson 1988, 79).

Norepinephrine serves as a kind of "printer" that fixes information into long-term memory and helps establish new synapses associated with memory. The release of norepinephrine as a result of shock, fright, or anger helps a person vividly remember information about the experience. Studies indicate that a person being deprived of norepinephrine can still learn new things, but they will not be able to remember what they were taught (Howard 2006, 56). An optimal level of norepinephrine provides us with the ability to react quickly and aggressively to situations presenting danger.

Using the metaphor of a vehicle, this neurotransmitter can be termed as a 'gas pedal' brain chemical. This is the fourth neurotransmitter to be introduced giving a total of two 'gas pedal' neurotransmitters – dopamine and norepinephrine, one 'brake pedal' neurotransmitter – serotonin, and the 'gas or brake pedal' action of acetylcholine. Again, acetylcholine can attenuate or decrease the impact of the results of the 'gas pedal' depending on the level of acetylcholine.

### The Chemical Building Blocks of Norepinephrine

Norepinephrine's precursor is dopamine – L-tyrosine converts into dopamine, which, in turn, converts into norepinephrine.

### Impact on Norepinephrine Levels

Perry (2002), of Baylor College of Medicine in Houston, has provided extensive research about the effects of post-traumatic stress disorders (PTSD) in children. His work has been helpful to parents and caregivers living

with children suffering with PTSD. Perry reports that more than 68 percent of children surviving the Branch Davidian siege at Waco, Texas in 1993 met the criteria for the diagnosis of PTSD. His study showed that all of the children had very high levels of norepinephrine, which can produce anxiety, excess energy, racing and pounding heart and increased blood pressure. What the scientists found was that the children's resting heart rate was at 100-170 beats per minute; the average for children is 84 beats per minute. The children had high levels of norepinephrine, which is typical of people with PTSD (Perry 2002, 9-12).

The flood of norepinephrine can reset the child's brain chemistry setpoint to a 'high alarm' state. These are children that are more prone to being impulsive, aggressive and more likely to commit hot-blooded violent criminal acts. Scientists state that in this sort of situation, kids adapt to the behaviors (meaning a resetting of the brain chemistry baseline) from high norepinephrine. These kids become more impulsive and hyper-vigilant and tend to be overly-reactive, and are more prone to act before they are acted upon in that kind of abusive setting (Kotulak 1996, 78-81).

### Norepinephrine and Antisocial Tendencies

Children might start off with high norepinephrine and demonstrate impulsive behavior (the high alarm state) but this will change around puberty such that their brain chemistry baseline might convert to low norepinephrine, low arousal and more predatory behaviors. The change may be due to the fact that brain cells that are exposed to constant stress burn out, thus dropping to a lower level of activity to save the cells. Scientists believe that these are kids that change from being victims to being victimizers and develop an incredibly icy cold quality of being emotionless. The only thing they are sorry about is being caught (Kotulak 1996).

## 5. GABA

### The Basic Biology of GABA

The fifth and last key brain chemical is Gamma-Aminobutyric Acid – GABA whose activity defines it as an inhibitory neurotransmitter. This is considered the brain's most important inhibitory brain chemical. GABA's primary function is to aid in reducing anxiety. Optimal levels of GABA result in muscle relaxation, comfortable sleep and an overall quieting effect. Lower levels of GABA are associated with increased anxiety and tension (Howard 2006, 57).

Using the metaphor of a vehicle, this neurotransmitter can be termed as a brake pedal brain chemical. GABA is the brain's most critically important brake pedal. To summarize the five neurotransmitters, there are two gas pedals – dopamine and norepinephrine; and there are three brake pedals – GABA, serotonin, and acetylcholine. We know that the level of acetylcholine, in the brain, can take the role of being a gas pedal which attenuates the impact of the gas pedal neurotransmitters; or acetylcholine can take the role of an inhibitory neurotransmitter that tempers the increasing excitatory (gas pedal) neurotransmitters with a braking action. So using the vehicle metaphor, there are two ways to stop a vehicle: ease up on the gas pedal or apply the brakes, and likewise there are two ways to accelerate a vehicle: apply the gas pedal or ease up on the brake pedal. When applying this metaphor back to neurochemistry, it helps explain different behaviors and moods.

### The Chemical Building Blocks of GABA

GABA is made from the amino acid glutamate with the aid of vitamin B6. Glutamate is present in large quantities throughout the body. A double blind, crossover study was published in *Biological Psychiatry* 14(5),

reporting that vitamin B6 was found to be more effective than methylphenidate (Ritalin) in a group of hyperactive children.

### Impact on GABA Levels

When low levels of GABA are found in combination with low levels of serotonin, this is a recipe for violence and aggression. Think about the vehicle metaphor. GABA and serotonin are both 'brake pedals.' Though serotonin exhibits a weaker braking action, it combined with GABA enhances the slowing of the 'gas pedal' neurotransmitters – dopamine and norepinephrine. So with lowered levels of both braking neurotransmitters, it is easy to understand that the revving action of two powerful 'gas pedal' brain chemicals – dopamine and norepinephrine - will dominate. Remember, there are two ways to slow the vehicle, easing up on the gas pedal or applying braking action. In this case, the brakes were unavailable.

### GABA and Passive Behavior

High levels of serotonin and GABA are associated with passive behavior. This statement is also easy to understand when relating it to the vehicle metaphor. When both inhibitory neurotransmitters are elevated this doubles the braking action. In this case it would be like the vehicle at a standstill. The braking action overrides the functions of the two excitatory neurotransmitters of dopamine and norepinephrine. Both of the excitatory neurotransmitters produce a feeling of alertness, and ability to experience situations with a healthy measure of assertiveness and aggression. In this case, using the vehicle metaphor, the way to bring balance is to ease up on the braking action to enable movement.

### GABA and the Impact of Media

Levels of GABA drop when a person is watching a television program with violence in action, which can set the stage for possible increased personal aggression. During the 1995-1996 school year, Singer, a researcher at Case Western Reserve University in Cleveland, Ohio, looked for precursors of violence in 2,245 public school children ages 7-15. The three strongest precursors reported were exposure to violence, lack of parental oversight, and television viewing habits - more than 20 percent reported viewing in excess of six hours a day (Howard 2006, 469).

### Summary

Social neuroscience is a fairly new discipline that will continue to develop over time providing a comprehensive understanding about behaviors and moods through integrating the research from social sciences and neuroscience. It is the writer's hope that this brief introduction to neurochemistry inspires participants to integrate this valuable information into their daily interactions with youth, and to perhaps seek further self-education. The goal is to inform, empower and encourage personal learning of the stewards of our youth and provoke a paradigm shift in relating to our children.

### Implications

Intensive full-day seminars have been given nationwide to hundreds of organizations with direct responsibility for over one million youth. The seminar curriculum provides a deep neuroscientific comprehension of why young people often make bad decisions. Participants have included professionals from schools, mental health, law enforcement, drug rehab, attorney and paralegals, and parents and community. The impact has been far-reaching as noted in feedback evaluations.

School social workers and counselors state they have changed their standard of care and support to students, through the in-depth understanding of the neuroscience of behaviors. They have said that fusing their training in psychology and the basics in neuroscience have expanded their ability to positively influence youth to making better choices. Some direct quotes from school social workers: “I will no longer ‘write-off’ a youth” and “This (program material) makes sense and I can’t label a youth out of frustration.” “I wish I had learned this while in graduate school.” Some K-12 schools are reviewing their school’s policies, and cafeteria menus to provide healthier choices. Many school social workers are building a stronger relationship with co-participants – School Resource Officers (sworn officers based in schools).

Law enforcement officers, safety officers and directors of safe and healthy schools have stated that the program information has aided in understanding their own brain chemistry, and with having an appreciation for what might be some root causes of youth behaviors, it has resulted in changing their approach to violent or difficult situations without using force or aggression. As one officer stated, “I’ve learned more about people in one day than in my 32 years in law enforcement. I wish I had learned this early in my law enforcement career.”

Questionnaires were administered prior to and at the conclusion of the seminar training to monitor changes in participants’ understanding of brain chemistry and their attitudes towards dangerous behaviors and delinquent and at-risk youth. The highly accessible format of the trainings has resulted in overwhelmingly positive feedback from the participants and demonstrably high comprehension of the material presented. Anecdotal evidence suggests that long-term retention is also high.

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