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Addiction through Three Different Perspectives

Jhoan Esteban Osorno, Carli Varmette, Kathryn Wells
Departments of Biology, Economics, and Psychology
Siena College
Loudonville, New York 12211 USA

Faculty Advisors: Karen Boswell, Ashley Provencher, Rachel Sterne-Marr

Abstract

There are many negative misconceptions tied to addiction that prevent addicts from receiving proper treatment. One of the most common misconceptions is that any type of drug consumption will result in addiction, or that all drug users are addicts. One of the challenges that is faced when discussing addiction is that every discipline may have a different perspective on addiction. An interdisciplinary perspective more holistically investigates a person's decision to consume drugs. Biologists view addiction as a chronic relapsing brain disease characterized by changes in the structure and function of the brain that results in behavioral changes. Similarly, psychologists believe that addiction is a behavioral manifestation of the malfunction of the brain's normal processes, resulting from chronic drug consumption. Economists, in accordance to some psychologists, argue that a person can be identified as an addict given their rational behavior. These specific disciplines were chosen because biology focuses on chronic consumption, economics focuses on behavioral consumption and psychology provides a strong bridge between the two. We conclude with a discussion of how these disciplines might jointly inform a discussion on the efficacy of drug prevention and drug treatment. Relapses are common, and a good treatment outcome should be a significant decrease in drug use with only occasional, if any, relapses. To achieve this, the most effective treatment might be a combination of multiple approaches stemming from each discipline.

Keywords: Interdisciplinary, Chronic Disease, Rational Behavior

1. Introduction

Why do people consume drugs like cocaine, alcohol, or ketamine? It's easier to find enjoyment in everyday life, it's easier to feel good, to socialize, and it's even easier to help forget the hardships of life when under the influence of mind and body altering substances. These claims provide a general, surface explanation as to why people may choose to consume drugs. However, there are many underlying factors that need to be addressed that influence an individual's decision to use. A person who is repeatedly consuming drugs to "forget about the bad things that happened at work today" is actually undergoing biological, psychological and economical alterations that are influencing their behavior and choices.

Individuals who use drugs repeatedly become vulnerable to addiction. Addiction is not well understood, and this lack of understanding leads to many negative misconceptions about an addicted individual. One of the most common misconceptions is that any drug consumption leads to addiction, or more strongly stated: all drug users are addicts. In most secondary schools, drug education programs teach drug abstinence by instilling the fear in youth that addiction is inevitable following first time use. Addicts are also characterized as victims of their social environment. Many believe that addicts lack the moral willpower to abstain from drug use. In addition, it is believed that addicts cannot stop once they are high and will always choose to take another dose. These ideas are just a few of the many common misinterpretations of addiction. Evidence suggests that all of the commonly held beliefs about addiction are inaccurate and the three fields of biology, psychology and economics can provide an ample investigation as to why.

These three disciplines complement each other in a way that provides a more comprehensive view on addiction than any of the perspectives on their own. Any one perspective alone is doomed to be lacking in at least one domain due to a lack of knowledge on the subject. This interdisciplinary perspective more holistically investigates why a person decides to consume drugs, how an addiction is formed, and attempts to define addiction collaboratively using numerous angles. Although addiction is difficult to define and there is no universally accepted definition, we offer a more nuanced explanation. We conclude with a discussion of how these disciplines might jointly inform a discussion on the efficacy of drug consumption along with optimal treatment and prevention strategies.

2. Methodology

TeamBILD (Big Issues and Leading-edge Discovery) is an interdisciplinary research program that brings together a team of three students, one from each of Siena College's academic schools, to examine "big" issue topics. The goal of the research is to present new insights on addiction, but in order to provide such insights the team first came across a road block on whether addiction was classified as a behavioral choice or a chronic disease. Through mentor guidance, each field of study was introduced to both views and encouraged to examine the different theories on addiction. The two contrasting views of choice versus disease became the topic of discussion and the overall consensus. Biologists portrayed that addiction is a chronic disease, while the literature in economics presented addiction as a behavioral choice. There existed a split of psychological thought that supported each of the two points of view.

In an effort to intertwine the three disciplines, it was required of the individuals to have an open mind to the other two disciplines until a common ground was met between all three disciplines. This mandated each field of study to delve into and become familiar with literature outside of their own fields of study and really focus on a multidisciplinary approach. A critical source of knowledge that started a prime investigation was Dr. Nora Volkow, an experienced psychiatrist as well as the director of the National Institute on Drug Abuse. Volkow's years of experience dealing with addiction provided insight supporting both addiction as a disease as well as addiction as a behavioral disorder of choice. Volkow and many other expert's thorough investigations helped build this multidisciplinary examination as well as introduce new and interesting ways to define addiction. It was necessary that the articles referenced for this research either criticized or supported the three characteristics of addiction; reinforcement, tolerance, and withdrawal. It was also required that the articles provided an opinion on the two contrasting views of addiction. Most importantly it was required that the articles used pertained to one of the three interdisciplinary fields. It was not necessary that the literatures chosen had an interdisciplinary approach to addiction, but the literatures gained immediate attention if they contained a discussion of more than one of the interdisciplinary fields.

3. Addiction through a Biological Lens

Among biologists, addiction is viewed as a chronic psychobiological brain disease. This disease is characterized as causing changes in the brain at the cellular, molecular, structural, and functional levels. These changes to the brain result in the abnormal behaviors associated with addiction.[1] It is considered a brain disease because an addict's brain undergoes persistent changes; research and imaging has shown significant alterations to the glucose metabolism and receptor availability in the brains of addicts.[2] The abnormal behavior that results is due to the dysfunctional brain tissue. This behavior includes compulsive drug seeking and consumption despite negative consequences.[3]

Tolerance and dependence are also defining characteristics of addiction. The addict needs more of a drug to get the same effect after multiple times using the drug and a need manifests that can be painful emotionally or physically when the user abstains.[4] In order to understand how addiction is considered a disease of the brain, it is important to understand how the brain changes after prolonged drug use and what occurs at the molecular and cellular level that results in the structural, functional, and behavioral changes that are consistent with the behavior displayed by addicts.

First, it is important to explain what is happening in the brain when a person uses a psychoactive drug. Although individual drugs affect the brain differently, drugs with the greatest abuse and dependence potential all impact the same pathway in the brain: the mesolimbic dopamine system or the reward system.[4] This is a pathway of communicating nerve cells. It originates in the ventral tegmental area (VTA) at the base of the brain and extends into the nucleus accumbens, a part of the brain involved in motivation and pleasure. The pathway also has projections into the frontal cortex and the amygdala that allow for regulatory feedback from other parts of the brain.[5] In a non-addicted brain, this pathway is responsible for ensuring that we pursue activities that benefit our survival, such as eating and

sexual reproduction, by making us feel good when we do these activities.[6] While many neurotransmitters are utilized in communication between neurons, dopamine in particular has proved to be important in drug addiction.[3] Drug use can alter the ability of these cells to communicate properly, thus impairing the reward system.

For example, a person eating a cheeseburger might experience a certain amount of enjoyment from eating it. This is because neurons in the VTA have been stimulated and released dopamine. The dopamine is dumped into a space between the VTA neuron and a neuron in the nucleus accumbens called the synaptic cleft. When the dopamine reaches the receptors on the nucleus accumbens neuron, a signal cascade causes the neuron to become excited. Further communications with other areas of the brain that process emotions will allow the individual to feel enjoyment from eating their cheeseburger. The communication ceases when a transporter protein removes excess dopamine from the synaptic cleft and other VTA signaling terminates.[5] Stimulants, like cocaine, and opiates, like heroin, act differently on the mesolimbic dopamine system to alter its function. Cocaine disables the transporter protein that removes excess dopamine from the synaptic cleft and dopamine remains in the area, which continues to stimulate the nucleus accumbens neuron. This stage is often referred to as feeling high.[7] Heroin acts on other neurons that modulate VTA neurons that suppress VTA signaling between the two neurons. If the regulatory neuron cannot turn off the communication, then dopamine continues to be produced and the person experiences a high.[7]

In a person who consistently consumes drugs, these cellular processes happen immediately after the administration of the drug, and there are many other changes that occur even after the high has ended. Chang *et al*. show with magnetic resonance imaging (MRI) that with chronic drug consumption, the frontal cortex of the brain become denser, dopamine receptors in the striatum become less available, transporter proteins are less abundant, and glucose metabolism is changed.[2] Chronic drug use also alters the responsiveness of the VTA and nucleus accumbens to the neurotransmitter glutamate. The amygdala, hippocampus and frontal cortex communicate with the mesolimbic reward system via glutamate to increase dopamine production in the pathway. Drug use can heighten responsiveness to glutamate and thereby increase dopamine production.[3] Another change that can occur over prolonged drug use is gene expression. Changes in gene expression can occur as a result of increased transcription factor function or changes in the structure of DNA itself that produce a different pattern of protein production.

Transcription factors are a class of proteins that are responsible for regulating the processing of DNA into protein. They can either increase or decrease the expression of certain genes by binding to them.[8] One of these transcription factors that acts in the short term is CREB (cAMP response element binding protein). This protein can be found in every cell of the body and has many functions.[9] CREB binds to a gene encoding the protein dynorphin. Dynorphin is produced by and exported from nucleus accumbens neurons where it binds to a receptor on VTA neurons to inhibit dopamine production. Thus, dynorphin increases tolerance because it reduces the efficacy of the reward system.[4]

Another important transcription factor that works in the long term is ΔFosB (pronounced delta fos B). This transcription factor is much more stable than CREB, allowing it to act for a longer period of time within the cell. After repeated exposure to drugs, ΔFosB concentration in nucleus accumbens neurons rises. This increased concentration has been linked to the growth of projections, or dendritic spines, from the cell.[10] ΔFosB binds to certain genes in the DNA that code for the growth of these dendritic spines. More spines on the cell allow for more surface area to facilitate more communication.[10] This amplification of communication creates a stronger response when drug related cues, like seeing the drug or related paraphernalia, are administered. Excessive amounts of ΔFosB within the cell has also been linked to hypersensitivity to drugs for this same reason.[4] Beyond ΔFosB, there are additional processes also involved in changing gene expression.

The study of epigenetics focuses on the changes made to an individual's genome without actually changing the sequence of the DNA. These changes alter how tightly or loosely the DNA is packed, which ultimately determines the pattern of protein production.[8] Epigenetics has recently been linked to addiction and the changes in gene expression can be correlated with the change in behavior.[4] One of these modifications to the DNA is histone modification. Histones are small proteins involved in keeping DNA tightly packaged. Chemical modification of histones with methyl or acetyl groups can either tighten or loosen the packaging of the DNA. When the DNA becomes more open, the genes are more likely to be expressed in the cell. The opposite is true if the DNA gets packaged tighter.[8] Amphetamine use has been linked to increased histone modifications at the gene that encodes ΔFosB. This modification thus reduces the production of ΔFosB in the neurons and leads to the decrease in the ability of the cell to effectively communicate as explained above.[10] It is clear how after prolonged use of amphetamines, the biological processes that occur in the short term are decreased when gene expression is changed.

There are many other cellular and molecular processes that occur in addiction and drug abuse, but ultimately it comes down to cell-to-cell communication. One of the most common receptors among all cells of the body is the G protein-coupled receptor (GPCR). The receptor for dopamine belongs to this family of receptors. When dopamine binds to the receptor, it results in a signal cascade that induces changes within the cell.[9] The next step in the cascade is to remove the receptor from the cell surface so that signal strength can be modulated or so the receptors can be

recycled back to the surface later. To remove the receptor from the cell surface, the receptor must be tagged with a phosphate. One class of enzymes responsible for adding the tag is called a GPCR kinase (GRK).[9] There are several different types of GRKs, and one in particular has been studied as a drug target for addiction. Mice lacking GRK6 in their nucleus accumbens are hypersensitive to cocaine and amphetamines.[11] This is a significant finding because it shows that by knocking out the GRK6 protein from the animal, they no longer acquire tolerance to the drug, which is a defining characteristic of addiction. Thus, in the future, drugs may be synthesized to inhibit GRK6 function. There are many other drug targets that are currently being researched, some of them being dopamine, glutamate and opiate receptor antagonists. These drugs would mimic molecules that bind to the receptor to inhibit their function. They are advantageous because they do not have to pass through the cell membrane to affect the target cell.

In summary, biologists view addiction as a disease of the brain because the brain is altered irreversibly in its structure and function. Thus, addicts are not irrational, immoral or victims of their social situation, even though an addict's environment may play a role in their decision to first consume drugs. Rather, they suffer from a brain disease. Chronic consumption of drugs causes changes in the mesolimbic reward pathway. That being said, this pathway is not severely altered after a single use. Chronic consumption of drugs is required to cause these changes to the mesolimbic reward pathway. Since this pathway is important in regulating motivation, the addict will now experience an increased motivation to consume the drug despite any negative consequences associated with the consumption. This abnormal behavior associated with drug consumption can be further examined through the lens of psychology.

4. Addiction through the Lens of Psychology

Psychologists view addiction as an extremely complex state that is influenced by biological, environment, social, and intrapsychic factors. A clinical psychologist would refer to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) to describe addiction.[12] The manual uses the term "substance use disorder" for the condition that is commonly referred to as addiction. As defined by the DSM-5, substance use disorder is "a problematic pattern of use of an intoxicating substance leading to clinically significant impairment or distress as manifested by at least two of the eleven possible characteristics within a 12-month period."[12] A few characteristics include, "the substance is often taken in larger amounts or over a longer period than was intended" and "there is a persistent desire or unsuccessful efforts to cut down or control use of the substance."[12] With the characteristics of addiction identified, psychologists seek to understand how addiction develops in an individual.

Psychologists hypothesize that addiction is a behavioral manifestation of the malfunction of the brain's normal processes, resulting from chronic drug consumption. On a behavioral level, psychologists recognize the importance of habits that are formed through conscious as well as unconscious behavioral conditioning. Psychologists differ among themselves in their classification of addiction as a biological or behavioral disorder. Some psychologists view addiction as a biological disorder (i.e. brain disease) in severe addicts but consider it to be a behavioral disorder in more mild cases of addiction. Others view addiction as a brain disease under all levels of severity or as strictly a behavioral disorder. Understanding both the biological as well as the behavioral mechanisms will help better explain the different viewpoints.

Changes in the brain lead to alterations in behavior. Examining behavioral manifestations of the putative changes in the brain that occur with chronic drug use, Volkow et al. describe how addicts lose control over drug consumption.[13] Volkow's "stop/go" model describes how the "stop" and "go" systems of the brain become disconnected as addiction develops. The "stop" system is the prefrontal cortex (PFC) and it is responsible for weighing consequences of actions and encouraging appropriate reactions. The "go" system is representative of the mesolimbic dopamine system mentioned previously that is responsible for arousal, pleasure and survival needs.[1] When a person is not addicted to a substance, the PFC and the mesolimbic dopamine system are integrated and work together to make the best decision for the overall well-being of the body.[13] For example, if you are hungry and a stranger next to you is eating a delicious looking cheeseburger, the go system would say, "steal the cheeseburger, we need food now," to keep the body alive and to meet survival needs. The stop system would say, "I know we're hungry but we'll be home in ten minutes and we can eat then" to prevent a negative consequence from the reaction of the stranger getting their sandwich stolen. Together, the stop and go systems make an overall beneficial decision. Contrary to properly operating stop and go systems, when a person is addicted to a substance, neuroadaptations lead to enhancement of the motivational aspects of drugs.[13] The stop system cannot restrain the go system from its need for pleasure because the chronic drug use weakens the functioning of the stop system. In an addicted individual, the pleasure that results from drug consumption becomes a necessity and is processed as part of survival by the mesolimbic dopamine system.[13] In addition, once the

substance has been ingested, the brain undergoes biological changes, mentioned previously, making it even more difficult to resist the urge to consume drugs in the future.

The psychological perspective also emphasizes the behavioral manifestations caused from chronic drug consumption. Both classical and operant conditioning are key processes that support the idea of learned behavioral manifestations. The concepts of classical conditioning were developed by Ivan Pavlov in the early 20th century.[14] In order to understand the role of classical conditioning in drug addiction, the terminology of classical conditioning is important to understand. An unconditioned stimulus (US) is a stimulus that elicits a reflex response, the reflex being the unconditioned response (UR). For example, an unexpected loud noise (US) may cause a person to yell or jump (UR). Next is a conditioned stimulus (CS) that when paired with an US or sometimes called a reinforcer, has the ability to elicit a conditioned response (CR).[14] For example, an addict who often receives drugs (US) from a person (CS) will tend to get excited and expect a high to come (CR) when they are around that supplier. When claiming classical conditioning as part of drug addiction we are explaining the unconscious portion of the behavioral manifestations. Once a drug (US) is presented with a group of people or in a certain environment (CS), a person will crave (CR) that drug when around those same people they have used with before or in that same environment they have used before. Time after time, if the same drug has been ingested around the same people and in the same places, the addict has been conditioned and taught that these environmental cues mean that drugs are coming. The addict does not realize that the people or their surroundings are causing their cravings, they just know they really want to use drugs at that moment and that is the unconscious part of their behavior. This is also the dangerous part of their behavior because it will lead to addiction if the conditioned stimuli are not recognized by the addict. Classical conditioning is an unconscious learning process that creates cues and triggers in an addict's environment that make it hard to avoid using. When the addict comes into contact with these environmental cues whether they be people, places, or objects a strong urge to use occurs and is difficult to resist.[14]

Unlike classical conditioning in addiction, operant conditioning involves voluntary behavior. Edward Thorndike studied trial and error learning in animals in the early 20th century. He referred to this type of learning as instrumental conditioning. It was later studied by B.F. Skinner and renamed operant conditioning. This learning process revolves around the idea that a person's behavior adapts to the demands of the environment. The individual must operate on the environment in some way to get rewarded.[14] The behavioral choice is based on the consequences of that behavior. When a person responds to a situation and satisfaction follows, that person is more likely to respond the same way the next time that situation presents itself. Skinner referred to this likelihood as positive reinforcement because a positive consequence is presented after a behavior is exhibited.[14] For example, if a person consumes a drug and a positive effect is experienced, they will most likely ingest that drug again to get that desired feeling in the future.

Negative reinforcement goes hand-in-hand with positive reinforcement and plays a major role in operant conditioning. Negative reinforcement refers to the increase of a certain observable behavior followed by escape from or avoidance of a negative consequence.[14] A person may choose to ingest a drug to avoid feeling withdrawal or craving. The action of taking the drug is still the exhibited behavior but it is reinforced with the loss of cravings or withdrawal symptoms.

The act of consuming drugs is dependent on biological changes and behavioral choices. However it is also important to take into consideration that the consumer will always choose the better option when given a series of choices. Heyman summarizes studies on human choice behavior and discusses the distinction between "local" and "global" choice.[15] In local choice, Heyman explains the better option as the item that currently has the higher value. For example, eating greasy fries because you are hungry seems like the best choice. In global choice, a series of choices made over a longer period of time will bring about the best result and will be the better choice.[15] For example, choosing not to eat greasy fries when you're hungry may prevent future weight gain as well as heart disease, making the end result of good health seem like the best choice. On a local, or short-term scale, a person gets an immediate reward of a high when they choose to consume drugs. An addict, in that moment, gives the reaction from the drug the highest value, taking a local perspective. In contrast, on a global or long term-scale, a non-addicted person gives the future reward of a healthy lifestyle, strong social relationships or more money a higher value. The choice to not consume a drug in order to benefit long term demonstrates a global perspective. Compared to an addict's "normal" day of drug use, an addict's first day of abstinence is valued remarkably low. The idea of refraining from drug use and waiting for a future reward seems less rewarding because they are accustomed to immediate satisfaction. Drug consumption, in terms of choice, can be described as the better option when taking a local perspective, characteristic of many addicted individuals.[15]

In relation to choice, the common misconception that addicts cannot stop once they are high and will always choose to take another dose over anything and everything is false. The choice to consume or not to consume depends on many things including the person's perspective, whether it is local or global. A person may have a certain local perspective one day and may choose to use drugs. However, their perspective may change the next day and they could

refrain from using drugs for alternative reasons. Heyman explained the underlying reasons for why some addicts "quit cold turkey" or have what seems like a "spontaneous recovery" from addiction.[15] Significant changes in circumstances, like the start of a new relationship or the beginning of a high-paying job may switch an addict's perspective from local to global. If an alternative reinforcer like money, food, or relationships presents itself and the addict values that alternative reinforcer more than the drug, they will choose the alternative.[16] One study in particular focuses on recruited addicts that were administered pharmaceutical-grade cocaine in the morning and then given chances throughout the day to take another dose of cocaine or receive a reward of five dollars in cash in the future.[16] When the initial dose of cocaine was high, the respondents would choose the cocaine over the money. They took a local perspective that the high was better then the future money. However, when the initial dose was low, respondents would choose the money over the cocaine. When the cash prize was raised to twenty dollars every respondent chose the cash.[16] The addicts were able to make global decisions, choosing the future twenty dollars when given the opportunity. Many addicts often lack alternative reinforcers like money or social support so the high elicited by a drug is incredibly appealing. A user's consumption of drugs can be understood in terms of his or her reinforcement history, and opportunities for alternative reinforcement. Addicts will not always choose to take another dose, especially when there are appealing alternatives present.

5. Addiction through the Lens of Economics

Economics is a social science that explores how people, businesses, and governments make choices to allocate scarce resources in order to satisfy their unlimited wants. Behavioral models are often used to predict future behavior given current and past behaviors. Neoclassical economic thought, or mainstream economics, builds its models from two fundamental assumptions: (1) people are rational and maximize their utility; and (2) resources are scarce. Utility is a numeric measure of the subjective happiness received by a consumer after consuming a good. Scarcity implies that consumers face a choice about which goods to consume in order to maximize their utility.

In modeling the behavior of an addict, it is assumed that the addict is rational and so, chooses to consume an amount of the addictive good that increases the addict's happiness. Specifically, the addict will choose to consume a drug as long as the marginal benefits received from consuming one more unit of the addictive good exceeds the marginal costs of consuming that unit. For instance, economists agree that "choice is based on the consequences of that behavior," but they dive even deeper into the reasoning and identify individual preferences as the driver of choice. The attractiveness of consequences is based on individual preferences for these outcomes. Though, positive effects of consumption are not always predicted (and so consumption may not always continue) if there are diminishing marginal benefits to consumption. Indeed, it is possible to consume too much so that the total level of happiness begins to decrease. For example suppose a person receives 5 utils of happiness from eating one cheeseburger and 9 utils from eating two cheeseburgers. The marginal utility gained from eating that second cheeseburger is 4 utils. The second cheeseburger might not be as satisfying at the margin as the first cheeseburger; the third cheeseburger might not be as satisfying at the margin as the second cheeseburger. The tenth cheeseburger might be dissatisfying!

The Rational Addiction Model formally models the utility received by an addict from consuming an addictive good.[17] The Rational Addiction Model describes a consumer's consumption behavior of addictive substances like cocaine, alcohol, coffee, gum, and other goods over time. Consumption is modeled over time, capturing current and future consumption of the addictive good. In terms of an addict, it is believed that their preferences are stable, but is it possible that through the biology of addiction that chronic consumption of the addictive substance results in changes to the brain to readjust the consumer's preferences. A limitation of this model is that there is no accurate way to measure the changing preferences of a consumer. Gordon Winton criticizes the model by exploring how a consumer will want to maximize the discounted value of alcohol, the prefered good that is being consumed, which means that the consumer is deciding to be an alcoholic because that is how the consumer will reach their greatest satisfaction.[18] There is a level of misconception on how to accurately monitor addictive behavior in Economics because The Rational Addiction Model assumes all users are addicts.

The Rational Addiction Model also assumes that the discount rate, a proxy measure of an individual's impulsivity to make a decision, is also stable. The discount rate, just as in any intertemporal model, discounts future benefits to the present value, assuming that gains received today are worth more than gains received tomorrow. Indeed, the discount rate is measured as the preference for immediate rewards divided by delayed rewards.[19] This means that relatively patient consumers have a lower discount rate than impatient consumers. Heyman's local and global choices can be compared to short-run and long-run decisions in economics – and thereby related to discount rates.[15] For example, the Marshmallow test designed first by Walter Mischel, tests an individual's ability to have delayed

gratification. This experiment relates closely to the discount rate in economics because it deals with the individual's impulsivity to make the immediate choice for the small reward of the marshmallow in front of them (high discount rate) or wait patiently for the small reward of two marshmallows, which is a low discount rate.[20] Since the discount rate is stable over time in the Rational Addiction Model, the consumer will not be more or less patient towards the utility gained from consuming the addictive good in the future than their patience in the present or past. Rationality is specifically defined as purposeful (goal-oriented) behavior that is practiced following marginal analysis. Marginal analysis is the weighting of marginal costs and marginal benefits to determine whether or not to participate in a particular activity (in order to achieve a goal). In relation to the stop and go system in the biology perspective, when the the stop system cannot restrain the go system from its need for pleasure is closely related to the consumer having a low discount rate due to the fact the chronic drug use will weaken how the stop system is functioning. The lack of a properly working stop system will result in the consumer being impatient when coming across the decision to continue to take the drug instead of seeing the withdrawals from chronic drug use.

The hyperbolic discounting rate replaced the original discount rate in order to more accurately model the impatience of addicts to receive the benefits from consuming an addictive good.[19] The hyperbolic discount rate serves as an exponential discount rate, an asymptotic discount rate that will demonstrate how a consumer has stable preferences across time, that is nested by (B=1). Hyperbolic discount rates are a representation of time-inconsistency, which means that the discount rate will not remain stable.[19] Hyperbolic discount rates propose a more accurate approach to monitoring addictive behavior than discount rates, which are constant because this discount rate helps better predict the changing demand of the addict. While using hyperbolic discount rates it can be determined by economists that drug consumers are not always addicted or abstinent and that there are consumers who consume the drug without reaching the state of mind in which they are considered an addict.

Economists employ a clear definition for addiction, which is predicted by the rational addiction model, requiring two conditions.[21] The first condition is that the consumer must exhibit tolerance: If a consumer consumes the same amount of an addictive good today as will be consumed tomorrow, the consumer will receive less utility from the good tomorrow. Tolerance implies that greater consumption today results in lower marginal utility tomorrow by increasing the value of the addictive capital stock tomorrow. In the same way as observed in the biological perspective, addicts need to consume more of the good to get the same effect. The second condition is reinforcement, or that consumption yesterday increases the marginal utility of today's consumption. The greater consumption of an addictive good today will increase the desire for consumption tomorrow. Or, greater consumption today will increase the marginal utility of consumption tomorrow. Rational consumers account for any future harm (cost) from consuming today in their calculus. This is often referred to as positive reinforcement as mentioned from the psychological perspective.[14] In contrast, consumption of a non-addictive good may not result in either of these outcomes. For instance, higher total utilities are received from consuming more of a good and marginal utility is diminishing at high levels of consumption. Although these two conditions are necessary to identify a person as an addict, a third condition may also arise: withdrawal. Withdrawal occurs when an addict abstains from consumption and experiences a negative physical reaction from this abstinence. In the biological perspective, withdrawal is known as dependence. This means that the consumer's satisfaction level is decreasing as the consumer reduces his level of consumption.

It is important to note that this model does not narrowly define addictive goods as drugs. In an effort to differentiate addiction from habits, Tomer specifies qualities of an addictive good that leads the consumer's experience with the addictive good to demonstrate: habit, harmful, dependent, craving, and deprivation symptoms.[22] It is important note that Tomer does not restrict addictive goods to only drugs, but also non-drug substances and behaviors such as gambling, sex, coffee, etc. In biology, an addictive good affects the brain and body in a harmful way, which Tomer describes as, "consuming the addictive commodity is expected to result in significant negative side effects of a psychological, social or physical nature," which is a representation of how drugs may affect the body and the brain.[22] In psychology and biology, the severity of the addiction demonstrates how harmful an addictive good may be. The severity of the addiction demonstrates how harmful an addictive good may be towards the consumer, so although goods such as coffee change the chemical makeup of the brain, it does not have as much of a negative impact as the way alcohol impairs the brain as well as structurally change the makeup of the brain. Tomer is suggesting a way to classify the addictive drugs from all other goods, which is important in improving the Rational Addiction Model to not always be a successful approach to monitoring addictive behavior.

6. Treatment and Prevention

The biological, behavioral, and social changes that addicts undergo should be addressed in treatment and prevention. In the biological model, addiction can be a chronic relapsing disease, much like diabetes.[2] Most commonly, it is more beneficial to manage a diabetic's symptoms rather than to cure the individual. The same should be true for the treatment of an addict. Complete abstinence is not always the best choice for an addicted individual and a variety of treatment techniques may be beneficial, depending on the individual, the drug they are addicted to, and the environment in which they live in. Relapses are common, and a good treatment outcome should be a significant decrease in drug use with only occasional, if any, relapses. To achieve this, the most effective treatment might be a combination of multiple approaches stemming from each discipline that fit the individual best.

There are many medications available to treat addiction including naltrexone, disulfiram, suboxone, methadone, subutex, topiramate and acamprosate.[23] Researchers continue to search for other potential medications, such as receptor antagonists. As mentioned previously, these drugs would bind to their specific receptor to inactivate their function. Transcription factors and GRK6 are also being studied as potential drug targets, but it would be much more difficult to find effective drugs that can pass through the cell membrane. Finding a drug that impacts the desired target protein or cell and does not have any adverse side effects in other parts of the body or in brain function is difficult. For example, dopamine is involved in so many functions other than the reward pathway, and targeting dopamine would cause serious impairment.[23] Other than medication there are also many behavioral treatments for addiction. Cognitive behavioral therapy (CBT) as described by the National Institute on Drug Abuse, is a therapy founded on the theory that in the production of maladaptive behavioral patterns like substance abuse, learning processes play a crucial role. Patients who are participating in CBT are taught to recognize and correct learned problematic behaviors by applying a large range of skills. These skills may include learning to cope effectively, governing self-control, weighing the positive and negative consequences of drug use, recognizing cues and triggers and identifying high-risk situations to avoid. Contingency management (CM) is another behavioral treatment. It is defined by the National Institute on Drug Abuse as a treatment strategy that involves supplying patients with rewards to reinforce positive behaviors such as abstinence. Through this approach, addicts still get the positive reinforcement of pleasure but not from the result of consuming drugs. For the most effective treatment, these medications combined with the right behavioral therapy will most likely foster the best results.[23] The medication will help manage the receptor activity while the therapy will help change and rebuild the behavior of the addict.

On top of medicinal and behavioral therapies, policy implications are another tactic used to help prevent drug addiction as well as first time use. The government uses strategies such as abolishing drugs, taxing drugs, and incarceration with the purpose of reducing the number of people who become addicted.[18] Taxing drugs is one of the strategies implemented in drug policies because it will decrease the desire for an individual to consume a drug. The cost of purchasing these goods would be expensive enough to discourage consumers. Taxes are relatively high on cigarettes and alcohol because they have social and environmental costs like pollution and crime. It is important to understand that taxes aren't used to target addicts.[18] Taxes are implemented on the entire population, affecting both addicts as well as non-addicted individuals who are consuming for recreational purposes. In addition to taxation, incarceration is another tactic used to prevent drug use and addiction. It removes the addict or substance abuser from the social environment that they are in. Incarceration isolates the consumer from the environment that played a large role in the consumer becoming an addict. Although it may not sound like the most moral approach, it is one way to prevent addiction. It is important to implement policies that will prevent addiction to compliment the different treatments available to the addict.

7. Conclusions

In comparison, when looking at the disease model of addiction, there are many overlaps with the psychological view relating to the brain. Biology and psychology are similar in their exploration of the relationship between underlying causes for certain behaviors. A person affected by addiction can experience biological modifications to their brain, resulting in unusual behavior.[1] However, what might differentiate the two disciplines is the level of analysis. The psychological perspective tends to focus more on the communication between the prefrontal cortex and the mesolimbic dopamine system as well as the individual preferences that result.[13] Modern biology explores the brain's overall communication, delving into more complex cellular and subcellular mechanisms. Psychology and economics can relate when considering how preferences are formed by a consumer. The positively reinforcing effects of addictive

goods lead a consumer to choose certain goods or substances over other alternatives like money.[14] The marginal benefits received from consuming a drug positively reinforces the observable behavior, thus increasing the consumer's likelihood to use in the future. Although economics and psychology agree that choice is influenced by consequences (ie. operant conditioning and individual preferences) the choice made by an addicted individual has a level of preference in economics, but not psychology. Psychology would reason that the addicted individual chooses to consume again because they know they will get positively reinforced with a high or negatively reinforced with the loss of a craving.[14] Economists would reason that the addicted individual chooses to consume again because they have a level of preference for the drug and they give the outcome of a high a certain attractiveness rating.[20]

By examining addiction through biology, psychology and economics, chronic drug consumption and the abnormal behavior associated with addiction can be explained in a thorough way. Drugs cause changes in brain function, which ultimately manifests abnormal behavior and leads to a change in the consumer's preferences. In all fields of study, there is a great amount of research that can be done to further examine addiction. In biology for example, it may be interesting to observe which genes are turned on or off as a result of chronic drug consumption. Researchers may also investigate the genes that make an individual more susceptible to becoming an addict. Researchers in the field of psychology may investigate further into addictive behavior and spontaneous recovery. Heyman describes spontaneous recovery as a shift from a local to a global perspective due to do a change in circumstances (i.e. new romantic relationships, job promotion).[15] However there is still research to be done on addicts who "quit cold turkey" without any circumstantial changes. Further research is arising such as Neuroeconomics, an interdisciplinary field that utilizes the foundations of psychology, neuroscience, and economics in order to better understand the human decision making process. Mainstream economic models such as the Becker and Murphy model only look into the outcome of a decision in comparison to the Neuroeconomic Drift Diffusion Model, which explores the decision making process. Neuroeconomics helps to investigate the addictive behavior of the individual using behavioral patterns from psychology and maximizing utility from economics. All three disciplines have the goal of preventing and reducing the number of addiction cases that exist and a holistic approach incorporating theories from all of the three fields provides a thorough background to achieve that goal.

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