Engineering Neurobiological Systems: Addiction

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KEYWORDS

• Addiction • Biological engineering • Neuropsychoanalysis • SEEKING • Opioid • Tobacco

KEY POINTS

- Psychodynamic treatment of addiction must take into account that there is an addictive drug industry, both legal and illicit, and that huge profits are made by injuring and killing people. This fact propitiates the therapeutic alliance between patient and analyst and minimizes countertransference stigma and frustration.
- Psychodynamic treatment of addiction requires an understanding of drug effects on the brain. Neuropsychoanalysis involves correlation of psychoanalytic psychology and clinical patient experiences with neurobiology and therefore fulfills this requirement.
- Engineering models are based on neurobiology. Models facilitate efficacy of treatment.
- A drug cannot be addictive unless it can change the ventral tegmental dopaminergic SEEKING system, resulting in changed thinking by the drug user. This change is best described as "mind control," meaning the drug user brings the drug seller money despite the user's knowledge of being injured and possibly killed by the drug.
- The SEEKING system is the neurobiological correlate of the will, the experience of drive operating within us. Knowledge that the will of the patient has been taken over by a drug dealer is required of the psychodynamic treater and must be interpreted to the patient.

INTRODUCTION

One hundred million people were killed by tobacco in the 20th century, and we are on track for 1 billion killed in the 21st century.[1] The chance of someone using illicit drugs is 80 times higher if they start inhaling cigarettes before the age of 15.[2] Given that the average age of onset of smoking is 13,[3] most victims are captured as children. Alcohol, the other addictive drug legal when the United States was founded in

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1789, kills 4% of the population.[4] Twenty-five percent of Americans die from using drugs (Table 1). Selling addictive drugs in the United States generates $845 billion per year, 5% of the gross domestic product (Table 2).

We know this, but not consciously. We act as if we have not noticed. The size of the mass killing is an order of magnitude greater than the holocaust or Stalin's murders. It is going on right now. The wish not to know is powerful. Words, the polar opposite of unconsciously driven destructive behaviors, are our solution. The psychoanalytic enterprise is to help make our patients and our society conscious.

The definition of addiction is, "Repeated use despite harm." If one inhales sticks of dirt, carcinogens, and nicotine, every stick creates harm. Social cigarette use is rare. Alcohol is more variable. One can drink every day and live to an old age. Alcohol and marijuana are drugs that usually affect people adversely when they start using in the morning. Most users do not become addicted. One of the problems about understanding drug addiction is that one cannot simply project one's own experience into another. The effect of drugs with addictive potential depends on the character of the person using the drug. Character function is complex and includes genetic predispositions. But genes are designed to undergo epigenetic changes, as humans develop in a social surround. We could say as an approximation that we are going to use psychoanalytic models to simplify the complexity of behaviors that have contributions from biological, psychological, and social sources.[5] However, in addiction, the neurobiology of addictive behaviors is so important that it is more accurate to call them engineering models.

ENGINEERING MODELS

"The purpose of an abstraction hierarchy is to hide information and manage complexity. To be useful, biological engineering abstraction hierarchies must allow individuals to work at any one level of complexity without regard for the details that define other levels, yet allow for the principled exchange of limited information across levels."[16] As defined by the International Council on Systems Engineering, "A system is a construct or collection of different elements that together produce results not obtainable by the elements alone."[17] Here we combine elements of neurobiology, psychoanalytic psychology, and the grim reality of the addictive drug industry and its victims, to construct a systems engineering approach to treatment and research.

Neurobiological concepts are used here to build engineering models. Arguments over whether every aspect of the model is correct are not important. Engineers

Table 1
Drugs kill one-fourth of Americans

Drug	American Deaths/Year
Tobacco	480,000
Alcohol	88,000
Opioid overdose	59,000
Benzodiazepine overdose	9000
Cocaine	6784
Methamphetamine	5740
Total deaths from drugs	648,524
Total deaths in United States	2,626,418

Data from Refs.[6–8]

Table 2
Income of addictive drug industry: $845 billion, 5% US gross domestic product

Industry	Sales ($ Billions)
Benzodiazepine	509
Alcohol	212
Tobacco	50
Marijuana—if legalized in the United States	45
Mexican/Columbian drug cartels	29
Opioid medications	19
Comparison—US auto	70

Data from Refs.[9–15]

want to make things happen in the real world. Addicted patients may die. We want engineering models that help them stay alive. Although the neuropsychoanalytic Addiction Medicine Service at the State University of New York uses at least 11 engineering models as a basis of making interpretations, this brief work considers a central model about drive and instinct to illustrate how the approach is used. A longer exposition about neuropsychoanalysis can be found in a work by Johnson and Mosri.[18]

THE SEEKING SYSTEM AND ITS INSTINCTUAL SUBORDINATES

Panksepp[19,20] used animal/brain pathway research to improve our ability to understand a notable confusion in Freud's thinking: the difference between drive and instinct. In neuropsychoanalysis, the psychoanalytic concept of drive is correlated with SEEKING,[18] a dopaminergic pathway that runs from the ventral tegmental area at the top of the midbrain along the basal forebrain; through the hypothalamus where it is tuned by inputs about food, water, and sex; and synapses with the nucleus accumbens. From this point, branches go to brain areas involved in motivated behaviors. Dopamine pathways are distinctly frontal and ventral—brain regions that are connected with motor function—in contrast with other neurotransmitters like norepinephrine or serotonin that stimulate the brain generally including all 4 cortical lobes and dorsal as well as ventral subcortical areas.

Plants don't need brains because they grow wherever a seed lands. Animals need a source of motivation to move through their environment to find the resources to stay alive and procreate. The particular goal of SEEKING shifts according to hypothalamic input. If the hypothalamus detects dehydration, the animal SEEKS water. If the animal drinks and then needs sex, the goal is shifted. There is no need for consciousness; this is a midbrain function. Consciousness tends to be awakened by the frustration of unpleasure,[21] of not automatically getting what is desired. Looking ahead to addiction, inhaling 20 cigarettes per day is not particularly conscious. It is only when in an environment in which the next cigarette is difficult to use that the addicted individual begins to think consciously about what to do to be able to inhale nicotine.

Although the SEEKING pathway constantly goads animals like us into investigating our environment, an activity that is pleasant in its own right, we have 6 instinctual (not drive) systems with identified neural pathways. CARE, LUST and PLAY are also pleasant. The CARE system of mammals is built on the LUST system present in many animals. Turtles lust after each other, creating fertilized eggs. The babies hatch and are on their own from birth. Mammals instinctually CARE for their children. They are just so darned cute! This feeling requires hormonal input to be experienced.[22] If

you are the older sibling of a newborn, you may have no feelings that this baby is cute. You are more likely to have RAGE turned on than CARE. Feelings about children change at puberty when hormones modulate both LUST and CARE systems.[22] PLAY is built into mammals to rehearse adult activities in a safe way. Children want to wrestle each other and their parents, rehearsing closeness without damage, rehearsing fighting, rehearsing competition. It feels good.

The pleasure principle is defined as a principle governing human psychological functioning, whereby unpleasure motivates psychological and behavioral activity.[21] We hate not to have what we want when we want it. We are happy to have pleasure but don't have it compulsively. We hate unpleasure and do everything we can to disengage from it. The next 3 systems generate unpleasure.

At the healthiest end of human relatedness, when someone impinges on us in a way that makes us angry (RAGE), we either move away from that person or if possible or talk through what they did that made us unhappy so that it doesn't happen again. Many people, especially children, feel trapped in human environments where RAGE is turned on constantly by interpersonal attacks. There is no talking things through. RAGE is complicated by a demoralizing sense of helplessness.

FEAR does not necessarily have anything to do with interpersonal relatedness. It is a signal that tissue damage may ensue. One can have this feeling when one gets near a cliff. Unfortunately, one can have it in one's own family. One of our patients was 11 when her father appeared to be beating his girlfriend to death. The father told her if she called the police, he would kill her too. The police were called by a neighbor, the girlfriend asked for a final kiss on her bloody, beaten face, believing that she would die. This kiss of the bloody, beaten face became a flashbulb memory. The patient developed posttraumatic stress disorder. When she got to work in the morning she was always careful to watch that another employee went in first, "In case a man was in the building who might kill me." Years later this patient experienced the "high" of alcoholic drinking as turning off the constant signal of fear that she might be killed any time.

PANIC is turned on by separation. Being with others feels great because of stimulation of the endogenous opioid system. Losing someone hurts. Panksepp explained that the PANIC system is built into animals so that they stay safely with others of their band.[20] It is evident in work with addicted patients that many people experience being completely alone, even in their family.

RAGE, FEAR, and PANIC are turned on in families in which parents behave badly, a common phenomenon. An epidemiologic study found that 25% of Americans meet the adult criteria for antisocial personality: 32% of men, 18% of women.[23] Behavioral manifestations include repeatedly performing acts that are grounds for arrest, conning others, aggressiveness as indicated by repeated physical fights, reckless disregard for the safety of self and others, repeated failure to sustain consistent work behavior or honor financial obligations, and lack of remorse: being indifferent to or rationalizing having hurt, mistreated, or stolen from another.

It hurts to be with people who are not emotionally available. New York University psychoanalyst Anne Erreich defined unconscious fantasy[24] as "a subset of the domain of mental representations, those concerned with conflicting wishes, affects, and defensive maneuvers." In a description of the function of unconscious fantasy, Erreich wrote[24]:

> *Avoidantly attached children have had innumerable experiences of having their neediness rejected by their mother, and so, despite signs of physiologic distress, they rebuff or ignore their mother when frightened, denying their neediness and/or*

doing to their mothers what has been done to them. Especially given what is known about the sophisticated cognitive abilities of even very young infants, it is hard to imagine an infant or toddler who doesn't initially register consciously its mother's rebuff. More likely the early accumulation of this type of experience turns initial awareness into an out-of-awareness prediction or expectation, resulting in a defensive inhibition of the subjective awareness of neediness, as well as need-seeking behavior. This dynamic eventually evolves into a characterological style of relating to self and others. As Paley (2007) puts it, "Since predictions incorporate past experience and learning, the past biases current experience. In a sense we learn to predict what to expect from the future and then live the future that we expect."

The unconscious fantasy of many addicted patients is that persons one depends on ignore one's need for closeness. This expectation is applied to current relationships. Even the most attentive psychodynamic clinician may not meet the needs of the avoidantly attached patient. For these patients, closeness constantly hurts. The relationship causes intolerable unpleasure.

The instinctual systems RAGE, FEAR, and PANIC are awful to experience. In families in which children are enjoyed and engaged, childhood is excellent. In families in which unpleasant feelings are constant and inescapable, teenagers look for drugs that turn off misery. Adolescents are the hardest addicted population to engage because they have just learned how to suffer less. They idealize their drug experience. They do all they can to escape treatment that they experience as having the potential to turn pain back on.

Another engineering model is fully developed in a report called Addiction and Will.[25] Adolescent drug use changes the SEEKING system. The psychology of the person reorients to accommodate the brain change. This is the denial system of addiction. If one listens carefully to patients who are explaining why they use drugs, the explanation actually makes no sense to an outsider. The explanation for drug use explains to the addicted person alone why they are using a drug that they know causes harm. For example, when asking someone why they inhale burning tobacco, a 50% mortality rate drug, one gets explanations such as, "We all have to die sometime," or "I need something to do with my hands," or "It relieves stress." The will of the addicted person has been taken over by the drug seller. The addicted person is not conscious that this has happened. Their experience is that they are the ones who want to use the drug. The reality is that by virtue of using a drug that changes the SEEKING system, other aspects of brain function shift to protect the false fitness signal as if the drug is necessary for life.[26]

Thus the sellers of addictive drugs have a product that controls the mind of the drug user. One notices, for example, that children frequently go from finding cigarettes aversive and begging their parents to stop, to urgently wanting cigarettes a few years later after beginning to use them. Now the SEEKING pathway demands food, water, sex, and nicotine. This neurobiologic change is the key to the finances of the addictive drug industry. If the drug seller can market the drug well enough to get people to take the drug into their brain, there is a brain change. The addicted person now has something that originated from outside them but has become permanently lodged within them. Abstinence despite constant SEEKING-mediated urges to use the drug again is the only way to escape further damage. No wonder step one of Alcoholics Anonymous starts with, "We admitted that we were powerless over alcohol." No wonder some people go to Alcoholics Anonymous for decades after becoming sober! Returning to use of tobacco or alcohol after falling under the influence of the sellers of the drug by virtue of a permanent brain change returns control of the person to the seller

of the drug. This is the mind control nature of addictive drugs. One is powerless over drug use.

Many conventional drug treatments involve supplying the type of drug that the patients are addicted to with little attention to character. For example, methadone maintenance involves staff that inspect each patient before dosing to look for signs of intoxication, high-tech systems pour the methadone dose, nurses observe drug ingestion. The whole treatment is oriented around supplying a drug in the opioid class and monitoring safe use. Outcomes at 4.5 years indicate more than a 1% annual mortality rate, 32% opioid-positive urine drug screens, and 4 days of heroin use over the last month.[27] This is the harm reduction approach to addiction treatment.

The alternative partially described here poses substantial challenges to the psychodynamic clinician. The patient is using drugs that threaten their life. Character issues that evolved during childhood make drug use appealing as a temporary solution to feelings that are experienced as intolerable. Psychological trauma is ubiquitous. Change in character structure is needed so that the automatic solution of drug use to stifle feelings is shifted to something safer and more long lasting as a solution. Outcomes for this type of treatment are unknown. Research support is needed to establish what happens to addicted persons who engage in patient-centered psychodynamic treatments that follow the lead of the patient's associations and dreams to address character issues and other fundamental disorders underlying addiction rather than instructional or medication-oriented treatments in which the help provided is determined by the philosophy of the treaters and applied to all patients in the same way.

How people get recruited to addictive drug use:

- They can't stand the constant trauma of RAGE, FEAR, and PANIC. They use drugs to turn the signal off. This form of addiction can be ameliorated by helping the patient deal with their repressed trauma via psychoanalytic therapy. The trauma is remembered, understood, and worked through, and the need to use drugs addictively goes away. This is called *psychological addiction*.[28,29]
- Repeated use of addictive drugs changes the SEEKING system. Noxious drugs become urgently wanted. This is called *physical addiction*. Physical addiction is forever. An Alcoholics Anonymous aphorism that describes this is, "You can't change a pickle back into a cucumber."

We might return at the end of this brief exposition about drug addiction to ask the question, "What is the difference between a psychoanalytic model and an engineering neurobiology model?" The answer has implications for both treatment and research. Although psychoanalytic models may mention biology, it is never clear how the biology fits in. The models are based on clinical interactions. They are psychological models. "I saw a patient. They used free association. This is what I understand to be a model to use in the treatment, and to communicate what I do to other psychodynamic clinicians."

Engineering neurobiology models use dual aspect monism.[30] This means there is a correlation between the neurobiology and the clinical interaction. Using the example above, that someone says, "I am smoking cigarettes because I need something to do with my hands." The patient is not asked, "What comes to mind about doing something with your hands?" Instead there may be a statement from the treater, "This is a sign that your brain has been taken over by the tobacco company. Your explanation makes sense only inside you. All you are doing is restating, 'I urgently want cigarettes.'" This is a specific situation in which a model built on psychology alone would render patient and treater helpless to address a potentially fatal addiction.

In terms of research, engineering neurobiology models give an alternative to using purely psychological concepts such as the reward pathway. We can see that there is nothing rewarding about drug use. The concept of reward is also a purely psychological construct based on animal observations that specifically left out the brain and simply counted conditioned responses to conditioned stimuli.[19(p12)] By using the combination of a psychological concept of unconscious fantasy along with the neurobiology of the SEEKING system, a neuropsychoanalytic approach, we can begin to think about how trauma, the human penchant to have fantasy, and the neurobiology of drugs in the ventral tegmental dopaminergic SEEKING system might generate results such as our case series in which 39% of opioid-addicted patients reported dreams of pursuing opioid use, whereas none of the patients who had been maintained on opioid medications as a treatment for chronic pain reported drug dreams.[31]

SUMMARY

1. We make no claim that the engineering models are "true."
2. The models are based on neuroscience combined with clinical experience.
3. Although animal research may contribute to models, the goal is to help humans. Therefore, models are congruent with human experiences.
4. Models improve outcomes for addicted patients including survival, physical and mental health, and function.

The models allow for interlocking concepts that form the backdrop of treatment.

1. Understanding the finances of the addictive drug industry undercuts a common countertransference that addicted patients are lying drug abusers, or that getting high is a hedonistic activity. It is the very opposite. Patients have been using addictive drugs since childhood to cut off horrible emotional signals about having been abused. Calling it *getting high* is best understood as a way to describe the relief of temporary escape from traumatic experiences and memories without having to consciously acknowledge unconscious fantasies that involve "mental representations, those concerned with conflicting wishes, affects, and defensive maneuvers." Addiction is a desperate adaptation to adverse human environments. As treaters we are trying to rescue a few of the victims of an unacknowledged mass killing unparalleled in human history. The methodology involves taking complex human experiences that are responded to behaviorally but not consciously understood and putting them painstakingly into words. Words and conscious representations of feelings, memories and experience counter the impulse to act addictively.
2. Addiction taking over the will informs our treatment approach. Explanations about why addictive drugs are used don't make sense to us. Treatment can be informed by this fact. An interpretation from the treating psychotherapist that their denial is simply reiterating, "I want to use drugs," may help the patient appreciate that this urgent, impelling wish is lodged permanently inside them.
3. Drive and instinct are nicely separated using Panksepp's 7 neural pathways. The SEEKING drive is overarching and will trump hedonic instinctual systems; LUST, CARE, and PLAY, which is why addicted patients neglect their lovers and children while single-mindedly pursuing drugs.
4. From a cultural view, we live in a society that tolerates legal profit making by killing with drugs. Children grow up under extremely adverse conditions and then become the victims of these killers. Awareness of this aspect of mass psychology locates patient and treater in a reality that informs their interaction.

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