According to Griffiths and Mumford (1), psychotropic substances that have the potential to be used as drugs of abuse share two essential features: 1) they have positive reinforcing properties, that is, they induce pleasurable effects; 2) they can harm the individual who uses them and/or society. Current conceptualizations of substance abuse tend to consider positive reinforcing properties and harmful effects as two largely independent features of drugs of abuse. This view is based on the assumption that hazards of substance abuse include adverse medical, psychiatric, and legal consequences, and that none of these consequences is strictly related to the capacity of drugs of abuse to induce pleasurable effects.

In this paper I will analyze the harmful effects of substance abuse from a different perspective, namely, that of Darwinian psychiatry (2). This perspective postulates a close relationship between the positive reinforcing properties of drugs of abuse and their harmful effects. In line with previous articles that have focused on the evolutionary aspects of substance abuse (3-5), the basic thesis of this paper is that the harmful effects of drugs of abuse include not only...
their adverse medical, psychiatric, and legal consequences but also their disrupting effects on the organization and implementation of adaptive behaviors. The paper is set out as follows. First, I will briefly summarize the evolutionary view of the human mind and of human behavior, with particular reference to the adaptive function of mental pleasure and positive emotions. Then, I will discuss how the capacity of drugs of abuse to directly stimulate the brain reward systems can have disrupting effects on the organization and implementation of adaptive behaviors. Finally, I will examine the clinical implications of an evolutionary analysis of the harmful effects of substance abuse.

THE EVOLUTION OF PLEASURE

An evolutionary account of the human mind and of human behavior is an account of how psychological and behavioral traits function as adaptations and how they vary across persons (6). When we say that a psychological or behavioral trait is functional or adaptive, we mean that it enhances the survival or reproductive success of the individual (or, at least, that it enhanced the survival or reproductive success of the individual in the ancestral environment). During the course of evolutionary history, natural selection favored psychological and behavioral traits that served a specific function over available alternative traits. Natural selection is strictly an a posteriori process which rewards current success but never sets up future goals. It is the observation that certain traits have advantageous consequences for their possessors in certain environments that accounts for their being favored. However, the a posteriori for the species is the a priori for the individual. In an evolutionary context, individuals can be viewed as strategists employing a variety of tactics to achieve biological goals. Human beings, like all other organisms, have been designed by natural selection to strive for the achievement of specific goals or experiences, such as acquiring resources, making friends, developing social support networks, achieving high status, attracting a mate, and establishing intimate relationships. In the ancestral environment, the achievement of these goals correlated consistently with a gene-transmitting advantage (i.e., increased fitness).

The achievement of adaptive goals often depends on a long chain of events and requires the implementation of complex behavioral strategies. For example, to achieve the ultimate goal of enhancing his own reproductive success, a person must correctly execute a variety of adaptive behaviors including identifying, selecting and acquiring a partner, accurately interpreting his/her needs and desires, and arousing his/her sexual interest. In each animal species, a variety of psychobiological mechanisms ensure the correct execution of each step of the evolved behavioral strategies aimed at the achievement of biological goals. In species characterized by a highly stereotyped behavioral repertoire, the implementation of adaptive behaviors can occur through a coordinated sequence of “fixed action patterns,” without any correlates in terms of emotional experience. However, in species characterized by greater behavioral plasticity and flexibility, natural selection has favored the evolution of brain reward systems as a means of guiding behavioral choices and of directing the individual toward the achievement of biological goals. The neuroscientist Jaak Panksepp succinctly expressed this concept: “Pleasure is nature’s way of telling the brain that it is experiencing stimuli that are useful” (7).

In humans, brain reward systems and the positive emotions originating from their stimulation play a central role in controlling the correct execution of adaptive behaviors. The capacity to experience mental pleasure and mental pain helps the individual to pursue goals relevant to biological adaptation and to avoid maladaptive situations. In other words, emotions have evolved to provide information about the costs and benefits of past, present, and future behavior.
(8). Under minimally adaptive circumstances, individuals experience mental suffering (e.g., depression) that functions in part as a warning system that one’s goal-seeking efforts are failing, and in part as a social signal to others to eliciting their assistance in achieving goals. Unpleasant emotions mold subsequent behavior by reducing the likelihood that one will behave in the same way again. Conversely, pleasant emotions associated with adaptive behavior are experienced as beneficial and increase the probability that one will engage in similar behavior in the future. In this context, it is clear why mental pleasure and adaptive behavior are so strictly associated. In natural conditions, brain reward systems were activated (indirectly) only by those stimuli that experimental psychologists and neuroscientists call “natural reinforcers” (e.g., food and sex) and that, in the language of evolutionary biology, correspond to the implementation of adaptive behaviors and the achievement of biological goals.

THE IMPACT OF DRUGS ON ADAPTIVE BEHAVIOR

The brain mechanisms of reward have been the subject of a substantial recent research effort, in which attention has focused increasingly on the mesolimbic dopamine system. This system originates in the ventral tegmental area (VTA) of the midbrain and projects forward through the basal forebrain bundle, to terminate in the nucleus accumbens, with some fibers extending further forward to the prefrontal cortex (9). As mentioned above, in natural conditions, this system can be activated (indirectly) only by those stimuli that experimental psychologists and neuroscientists call “natural reinforcers” (e.g., food and sex) and that, in the language of evolutionary biology, correspond to the implementation of adaptive behaviors and the achievement of biological goals. However, since the discovery of Olds and Milner in 1954, we

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**Fig. 1** - In normal conditions, pleasure is the final step in a sequence of events that starts with the execution of adaptive behavior, proceeds through the achievement of a biological goal, and ends with the activation of the brain reward systems. Pleasure is the psychic reflection of doing the “right thing” biologically. Numbers indicate the sequence of events.
know that the brain mechanisms of reward can also be stimulated directly through different artificial means.

In Olds and Milner’s original experiment (10), rats were implanted with electrodes located in the septal area and were allowed to self-stimulate through lever pressing. The finding that electrical self-stimulation reinforced lever pressing behavior demonstrated the existence of specific neural pathways mediating hedonic behavior. The experiment is considered a milestone in the history of neuroscience because it introduced a new technique, intracranial self-stimulation (ICSS), that has since been extensively used, and because it paved the way for the localization of the brain regions controlling reward. However, another important finding of Olds and Milner’s experiment was the devastating impact of ICSS on the adaptive behavior of implanted rats. While engaging in ICSS, these animals largely neglected any other activity and were no longer attracted by natural rewards such as appetizing foods and sexually-receptive females.

Drugs of abuse act in a way that is analogous to that of ICSS: they directly interact with specific receptors in the brain that normally help mediate feelings of satisfaction and pleasure associated with the execution of adaptive behaviors. Direct chemical stimulation of these receptors creates a signal in the brain that indicates, falsely, the achievement of biological goals. The individual who uses drugs such as opiates or psychostimulants no longer needs the presence of natural rewards to experience the positive emotions that, in normal conditions, are the psychic reflections of doing the “right thing” biologically. Drugs of abuse break the link between pleasure and adaptation, a link that is the product of millions of years of evolution. Figure 2 outlines this “decoupling effect” of drugs of abuse and its consequences on adaptive behavior.

![Diagram](image_url)

Fig. 2 - Drugs of abuse disrupt the natural chain of events leading to the subjective experience of pleasure. Direct stimulation of the brain reward systems makes execution of adaptive behavior and achievement of biological goals no longer necessary to experience pleasure. Numbers indicate the sequence of events. Dotted lines indicate missed causal relationships.
Clinical descriptions cite social and occupational impairment among the adverse consequences of substance abuse (11). When viewed from an evolutionary perspective, this kind of impairment greatly overlaps with disruption of adaptive behavior. However, social dysfunction associated with chronic use of opiates and psychostimulants has been commonly explained i) as a reflection of cognitive impairment and psychiatric symptoms caused by drug intoxication, ii) as the result of social ostracism elicited by the adoption of an anti-conventional lifestyle, or iii) as secondary to the legal troubles caused by the use of illicit drugs. Darwinian psychiatry suggests that another factor is likely to play an important role in causing drug-related social and occupational impairment: the inhibition of the incentive systems that normally motivate the individual to explore and investigate the social environment in order to get natural rewards. Through the availability of drugs, the individual no longer needs to vigorously pursue courses of action to experience the entire range of positive emotions that may derive, for example, from the establishment of intimate relationships or the achievement of competitive success. When the individual is drawn into the vicious cycle of self-stimulation of brain reward systems, everything else in the world drops in his/her value hierarchy.

For two different reasons, the Darwinian model should be considered a heuristic hypothesis rather than a comprehensive explanation of the hazards of substance abuse. First, whereas there are many data on the medical and psychiatric complications of drug addiction, very few studies have addressed the question of how much substance abuse impairs adaptive behavior in human subjects. Some preliminary data are in accord with evolutionary predictions [e.g., child neglect observed in new mothers addicted to opiates (12) and the “amotivational syndrome” of chronic cannabis users (13,14)], but we need further evidence to assess the validity of the model. Second, it is unlikely that all drugs of abuse have the same impact on adaptive behavior. In this regard, a variable that might be important is the effect of the drug on the “wanting” and “liking” components of reward. All adaptive behaviors include an appetitive phase (pursuit of a reward) and a consummatory phase (obtaining the reward) (4). The appetitive phase (that corresponds to the “wanting” component of reward) is mediated mainly by the dopamine system whereas the consummatory phase (that corresponds to the “liking” component of reward) is mediated mainly by the opioid system (9). Mimicking consummatory pleasure, drugs that arouse the opioid system (e.g., heroin) may have a greater impact on adaptive behavior than drugs that arouse the dopamine system (e.g., cocaine and amphetamines) and that have incentive properties. In effect, at high doses, opiates dramatically reduce the desire for practically all natural rewards (7).

CLINICAL IMPLICATIONS

The Darwinian analysis delineated in this article has several implications as regards the diagnosis, prevention, and treatment of substance abuse. When assessing the harmful potential of any drug of abuse, evaluation should not be limited only to medical, psychiatric, and legal problems. The impact of the psychoactive substance on the organization and implementation of adaptive behaviors should be included among the variables to be assessed. Minimization or elimination of adverse medical, psychiatric, and legal consequences would not make the use of drugs of abuse biologically safe. A related implication is that, under the rubric of potential “drugs of abuse”, we should include not only chemical substances but also other artificial ways of inducing mental pleasure. For example, in the next few decades, the technology of virtual reality is likely to progress until
the point is reached at which the user will be able to interact with virtual partners through the concomitant stimulation of all sensorial channels. Simulating the exposure to situations associated with natural rewards, this technology could activate the same neural pathways that are activated chemically by drugs of abuse. In terms of medical and legal risks, in all probability virtual reality will be a “clean” product compared with the psychotropic substances currently used as drugs of abuse. However, its potential capacity to alienate the individual from the natural sources of satisfaction and joy (that, in our species, are mainly related to personal relationships) could have a major disrupting impact on social functioning.

As regards prevention and treatment, the Darwinian perspective suggests that maximizing the exposure to natural reinforcers (especially those related to social interactions) is a key factor in decreasing the risk of acquisition and maintenance of drug addiction. Individuals living in distressing social environments or who have a suboptimal capacity to manage their social interactions can attempt to compensate a low baseline level of exposure to natural reinforcers with substance abuse. For these individuals, self-administration of drugs becomes a fast and easy way to experience pleasure, especially if the “drug” is legal and readily available (e.g., alcohol, tobacco, snack foods). Similarly, because natural and artificial reinforcers compete to stimulate the same brain mechanisms of reward, an increased exposure to natural reinforcers is likely to reduce the use of drugs. Data from clinical and experimental studies are in accord with these hypotheses. A considerable percentage of individuals who enter the vicious cycle of substance abuse initially take drugs to self-medicate a pre-existing condition of depression and mental distress (15). In laboratory animals, food deprivation increases drug-maintained behavior, and this generalizes to different species, routes of administration, and reinforcement schedules (16).

Natural reinforcers in a clinical setting reduce cocaine intake (17).

I wish to conclude with a note of clarification about the social and ethical implications of the ideas expressed in this article. A major problem with the application of evolutionary theory to human behavior is the risk of misinterpretation. When human behavior is analyzed from an evolutionary perspective, the concept of naturalness often enters into the discussion, and the question of what is natural and unnatural usually turns into a question of what is good and bad in social terms. In the field of ethics and morality, the term naturalistic fallacy has been used to denote the erroneous translation of evolutionary explanations of human behavior into normative or prescriptive terms. The naturalistic fallacy consists of the offering of some supposedly neutral descriptive statement about what is allegedly natural in such a way that, by itself, it implies some conclusion about what is in some way commendable.

The risk of running into the naturalistic fallacy is high when the Darwinian approach is applied to the problem of how to consider and treat people using drugs, an area of debate in which social consensus is limited, conflict-ridden, and often glaringly inconsistent. A correct application of evolutionary knowledge should not necessarily lead to the conclusion that any non-sanctioned use of drugs should be prohibited because it is unnatural or maladaptive for people to achieve pleasure chemically. Biological adaptation is a scientific concept, not an ethical value, as clearly indicated by the fact that, in modern industrialized societies, many maladaptive behaviors are permitted (e.g., birth control), encouraged (e.g., adoption of unrelated children) or even imposed (e.g., monogamy and sexual fidelity). Whether or not artificial means to achieve pleasure should be condoned by social norms is a decision that should be taken on the grounds of medical data and cultural considerations, not of evolutionary arguments.
REFERENCES