Chapter 2

How do you know you have a drug problem? The role of knowledge of negative consequences in explaining drug choice in humans and rats

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Abstract

Choice models of addiction raise a stark puzzle. Why, if addicts are able to control their consumption and choose to abstain in many circumstances, do they routinely choose to continue to use despite negative consequences? We delineate four options available to a choice theorist to explain this puzzle with respect to human addicts; describe recent experiments with addicted rats which determine the conditions under which they do and do not choose alternative goods over cocaine and heroin respectively; and consider how this animal research bears on our understanding of the nature of addiction. We conclude by arguing for the importance to addiction research of the popular notion of "denial" which, paradoxically, we can begin to theorize by appeal to animal models: for the puzzle dissolves if addicts do not know that the choice to use is the cause of negative consequences, as rats, given their cognitive limitations, cannot.

1 Introduction

Addiction has harrowing consequences. It can destroy people's bodies, causing disease and death. It can damage people's brains, causing cognitive impairment. It can cause and exacerbate mental health problems, such as depression, anxiety, and psychosis. It ruins relationships. People lose their families and friends, their jobs and social standing, their sense of having a community to which they belong. It can be a source of terrible shame, self-hatred, and low self-worth.

The orthodox conception of addiction is a chronic, relapsing neurobiological disease characterized by compulsive drug use despite negative consequences such as these.[1] This

[1] We include alcohol, as well as all common illicit and pharmaceutical drugs of abuse, in the reference of the term "drugs."

conception is common to the American National Institute of Alcohol Abuse and Alcoholism, the American National Institute of Drug Abuse, the American Medical Association, the British Medical Association, and the World Health Organization, and reflected in the clinical description and diagnostic criteria in the *Diagnostic and Statistical Manual of Mental Disorders* Fifth Edition (DSM-5) and the *International Classification of Diseases and Health Problems* (ICD-10). The prevalence and power of this orthodoxy can in part be explained by its capacity to resolve the puzzle inherent in addiction. Common sense suggests that, if people know that an action will bring about negative consequences, and they are able to avoid it, then they do. We act, so far as we can, in our own best interests and the interests of others we care for. This is a basic folk psychological rule of thumb for explaining and predicting human action. But this is what addicts seem not to do. Although addiction has harrowing consequences, addicts continue to use drugs.

Understanding addiction as a chronic, relapsing neurobiological disease characterized by compulsive drug use resolves this puzzle. The explanation is that addiction "hijacks" the brain, to use a common metaphor, thereby "nullifying any semblance of voluntary choice" (Charland 2002, p. 41) so that addicts lose all control and cannot help taking drugs, despite the consequences and against their best interests. As Carl Elliott describes it, addicts "must go where the addiction leads [them], because the addiction holds the leash" (Elliott 2002, p. 48). Hence the puzzle of why addicts use drugs despite negative consequences is explained: if addicts could avoid using drugs, they would—but they can't, so they don't.

The orthodox conception of addiction is challenged by evidence indicating that, however hard it is for addicts to control their use, and important for others to recognize this hardship, addicts are not compelled to use but have choice over their consumption. There are multiple sources of such evidence. Anecdotal and first-person reports abound of addicts (including those with a DSM-based diagnosis of dependence) going "cold turkey" (Heyman 2009, 2013). Large-scale epidemiological studies demonstrate that the majority of addicts "mature out" without clinical intervention in their late twenties and early thirties, as the responsibilities and opportunities of adulthood, such as parenthood and employment, increase (for a review of the empirical data see Heyman 2009, Heyman and Mims, Chapter 21, this volume; cf. Foddy and Savulescu 2006; Peele 1985; Pickard 2012). Rates of use are cost-sensitive: indeed, some addicts choose to undergo withdrawal in order to decrease tolerance, thereby reducing the cost of future use (Ainslie 2000). There is increasing evidence that contingency management treatment improves abstinence and treatment compliance, compared to standard forms of treatment such as counselling and cognitive-behavioral therapy, by offering a reward structure of alternative goods, such as modest monetary incentives and small prizes, on condition that addicts produce clean urine samples (for a review see Petry et al. 2011). Experimental studies show that, when offered a forced choice between taking drugs or receiving money then and there in the laboratory setting, addicts will frequently choose money over drugs when offered the choice (Hart et al. 2000; Hart 2013). Finally, since Bruce Alexander's seminal experiment "Rat Park" first intimated that something similar might be true of rats (Alexander et al. 1978, 1985), animal research on

addiction has convincingly demonstrated that, although the majority of cocaine-addicted rats will escalate self-administration, sometimes to the point of death, if offered no alternative goods, they will forgo cocaine and choose alternative goods, such as saccharin or same-sex snuggling, if available (Ahmed 2010; Zernig et al. 2013). Broadly speaking, the evidence converges to indicate strongly that addicts are able to control their consumption and choose otherwise in many circumstances. Drug use is responsive to incentives: addicted humans and rats alike are able to forgo drugs when motivated to do so.

However, the emergence of a choice model of addiction as a rival to the orthodox conception raises the puzzle in stark terms. Why, if addicts are able to control their consumption and choose to abstain, do they routinely choose instead to continue to use despite negative consequences?

Our aim in this chapter is to begin to answer this question. In section 2, we delineate the options open to a choice theorist to explain the puzzle with respect to human addicts. In section 3, we describe recent experiments with addicted rats which determine the conditions under which they do and do not choose alternative goods over cocaine and heroin respectively. Finally, in section 4, we bring sections 2 and 3 together and consider how this animal research might bear on our understanding of the nature of addiction. To anticipate, the overarching aim of the chapter is to argue for the importance of a better philosophical and scientific understanding of the popular notion of "denial," which, paradoxically, we can begin to theorize by appeal to animal models. For, put simply, the puzzle dissolves if addicts *do not know* that the choice to use is the cause of the harrowing consequences, as rats, given their cognitive limitations, can never do.

2 Explaining the choice to use drugs despite negative consequences

In asking why addicts use drugs despite negative consequences, it is paramount to recognize that there is no puzzle *at all* with respect to why people use drugs in the first place. Alongside factors such as peer pressure and cultural availability, drugs are instrumental means to valuable ends, which people may want to secure and can easily learn that drugs facilitate. Muller and Schumann (2011) delineate the following well-established functions for non-addictive consumption: (1) improved social interaction; (2) facilitated mating and sexual behavior; (3) improved cognitive performance; (4) facilitated recovery and coping with psychological stress; (5) self-medication for mental problems; (6) sensory curiosity—expanded experiential horizon; and, finally, (7) euphoria and hedonia. Put crudely, drugs can be pleasurable—they make us feel good. And apart from their inherent pleasure, they help us do various things we may want to do, like feel relaxed at a dinner party, have the confidence to flirt and dance, or de-stress after a hard day. Of course, the risk of addiction, alongside the possibility of moral condemnation and legal sanction, may deter some people from using some drugs, some of the time. But that does not affect the basic point that, broadly speaking, drugs are means to multiple valuable ends.

Addiction occurs when use escalates and comes to dominate and adversely affect a person's life. Importantly, from a clinical perspective, as embodied both in the DSM-5 and the ICD-10, there is no sharp divide between heavy and problematic use and diagnosis with a disorder (cf. Wakefield and Schmitz 2014). In addition to the physiological symptoms of tolerance and withdrawal, the diagnostic criteria are polythetic and include: cravings and a sense of compulsion to use; increased fixation and amount of time spent using and recovering, in conjunction with the neglect of other pleasures and activities; struggle to control levels of use despite efforts; serious negative consequences due to use with respect to physical and mental health, relationships, and roles and responsibilities; and, finally, persisting in using despite knowledge (DSM-5) or clear evidence (ICD-10) that it is causing or exacerbating such problems (APA 2013; WHO 1992).

Our understanding of the acute and chronic effects of drugs on the brain is ever increasing (Koob and Le Moal 1997; Koob and Volkow 2010). For instance, drugs directly affect levels of synaptic dopamine as opposed to affecting them only indirectly via the normal neural processes subserving learning and reward. Alongside other processes, such as incentive sensitization, this may explain why drug cues become unusually salient and cause unusually strong motivations to use (Redish et al. 2008; Montague et al. 2004; Robinson and Berridge 2008). However, like most mental disorders, and as apparent in the diagnostic criteria, addiction is not diagnosed via neurobiological mechanisms, but rather via psychological states and behavioral patterns identified at the personal level that cause distress and impair functioning (cf. Graham 2010; Stephens and Graham 2009; Levy 2013). This is part of why, especially given the polythetic nature of the criteria, there can be no sharp clinically derived line between heavy and problematic use and diagnosis with a disorder.

Consider, first, the obvious but important point that different people have different conceptions of how they want to live, and, correspondingly, are distressed or disturbed by different things. Although many, perhaps most, addicts feel shame, self-hatred, and low self-worth about their addiction, there may be some addicts, within some sociocultural contexts, who embrace their identity more willingly (cf. Flanagan 2013, Chapter 4, this volume). If this is so, and if drugs are readily available, then the fact that a person craves drugs, or that their life revolves around drugs, may not be experienced as a problem. Correspondingly, there may be no attempt whatsoever to control use.

Relatedly, different life circumstances may protect people more or less well against impaired functioning (for a review, see Martin et al. 2014). For example, it is well known that addiction is associated with low socio-economic status alongside other mental health problems (Compton et al. 2007; Heyman 2009). But, in so far as addiction is diagnosed via negative consequences, wealth, alongside other forms of privilege, may offer a protective factor (cf. Matthews 2014; Schmidt et al. 2010). For example, a wealthy mother who drinks heavily but can afford a live-in nanny to ensure her children are adequately cared for is able to meet more of her role-related responsibilities than a poor woman who drinks equal amounts but whose children go hungry and miss school. The consequences are more serious by shared social standards in the latter case than the former, and so too, as a result, is the likelihood of a diagnosis.

The implication that individual differences in conceptions of how to live and life circumstances can affect the likelihood of a diagnosis may give pause.[2] Indeed, Martin et al. (2014) have proposed that the negative consequences of use should be considered ancillary rather than core features of addiction for this very reason, namely, that they introduce significant individual and context specificity. However once we acknowledge that drug use in itself is not indicative of any form of disorder, but rather offers instrumental means to fulfilling valuable ends, the idea that negative consequences are fundamental to the pathological nature of addiction becomes evident. For it is only when the costs exceed the benefits, and yet use continues, that there is reason to believe that anything is *wrong*.[3] And, whether or not the costs exceed the benefits will, evidently, depend on individual differences in conceptions of how to live and life circumstances.

Why then, if addicts are able to control their consumption and choose to abstain, do they routinely choose instead to continue to use in the face of harrowing consequences? We suggest there are four possible forms of explanation.

2.1 Addiction and self-harm

Some addicts may choose to continue to use, not only *despite* harrowing consequences, but *because* of them. We noted above that the assumption that people act in their own best interests is a basic folk psychological rule of thumb. But there are exceptions, particularly with respect to people from underprivileged backgrounds characterized by childhood adversity and mistreatment, and who may struggle with a range of mental health problems associated with addiction, especially personality disorders.[4] People with such complex needs, and for whom shame, self-hatred, and low self-worth are strong within their sense of self, may deliberately and directly self-harm[5]—most notably through self-directed violence, such as cutting and burning, but also by other means, such as sexual and other forms of risk-taking behavior, overdosing, and, arguably, drug abuse quite generally. For some addicts, they may not care about themselves enough to care about the negative

[2] Note, however, that this arguably is a feature of most diagnoses of mental disorders. For discussion see Graham (2010); Glover (2014); cf. too Murphy (2015).

[3] Note for clarity that we do not claim this point refutes a disease model of addiction that identifies addiction with neurobiological dysfunction. On such a model, the pathology is wholly neurobiological: what is *wrong* or *disordered* is the functioning of the addict's brain. Rather, we understand this point as highlighting a counter-intuitive commitment of such a model, namely, that in identifying addiction with neurobiological dysfunction, it entails that addiction can in principle occur in absence of any personal-level negative consequences or harm—in other words, individuals may count as addicted, on this model, even when costs in no way exceed benefits and there is no evidence of a problem (cf. Levy 2013; the model will also, of course, need to specify what the brain dysfunction is, and why it should count as such, without appeal to any negative consequences or harm). It is open to adherents of a disease model to embrace this commitment, but it is, arguably, revisionary of the concept of disorder in general, and the construct of addiction in particular. For discussion, see Stephens and Graham (2009); Murphy (2015).

[4] For discussion see Maté (2009); Pickard and Pearce (2013).

[5] For discussion see Hawton et al. (2012); Motz (2009); Pickard (2015).

consequences of their drug use—indeed, they may, both consciously and unconsciously, embrace these consequences, in keeping with their sense of self as a person who is bad or worthless, and so deserving of them. In such cases, the costs of drug use in effect count as benefits from their perspective. Fundamentally, the problem lies less in the choice to use, than in the self-destructive mindset that this choice serves.

2.2 Addiction and psycho-socio-economic context

Some addicts may choose to continue to use, notwithstanding the harrowing consequences, because the benefits nonetheless outweigh the costs given a realistic appreciation of their circumstances and the options available (Pickard 2012). As noted above, the majority of addicts "mature out" in the late twenties and early thirties. Those for whom addiction remains a chronic problem are typically people from underprivileged backgrounds who also suffer from co-morbid mental disorders, particularly anxiety, mood, and personality disorders, and who of course must equally face the stigma, stress, and other problems associated with long-term poor mental health (Compton et al. 2007; Regier et al. 1990) and lack of psychosocial integration (Alexander 2008). The "self-medication" hypothesis has long been a staple of clinical understanding of drug use (Khantzian 1985, 1997; cf. Muller and Schumann 2011). It is common knowledge that drugs offer relief from psychological distress: we "reach for the bottle" or "drown our sorrows" when in need. For many chronic addicts, drugs may provide a habitual and, in the short-term, effective way of managing psychological distress, caused by negative emotions alongside other symptoms and problems typically experienced by people with mental health problems living in impoverished circumstances. Put crudely, drugs and alcohol offer a way of coping with stress, pain, and misery when there is little possibility for genuine hope or improvement. For addicts in such circumstances, the cost of abstinence is likely to be very high, for the benefits of drug use are many, and the alternative goods available are few. In such cases, the problem lies less in the choice to use than in the psycho-socio-economic circumstances that cause suffering and limit opportunities.

2.3 Addiction and temporal discounting

Some addicts may choose to continue to use, because at the moment of choice, they value drugs more than they value a possible but uncertain future reward, such as improved wellbeing with respect to health, relationships, or opportunities, which is consequent on long-term abstinence. The disposition to discount the future relative to the present is a common feature of human psychology, standardly considered rational to the extent that, adjusting for the relative value of the rewards, the present reward is certain while the future reward is uncertain. But in addition, human discount curves are typically hyperbolic, so that as a reward nears in time, its expected value increases sharply, creating shifts in preferences over time simply in response to current availability (Ainslie 2001; cf. Heyman 2009). Addicts have steeply hyperbolic discount rates compared to the norm (Bickel and Marsch 2001; Bickel et al. 2014). When the drug is within immediate reach,

its value skyrockets and addicts may at that point in time prefer use to abstinence, even if, when the drug is not within reach, they value it less than the possibility of improved wellbeing consequent on long-term abstinence and so, at that point in time, prefer abstinence to use.

Ambivalence is characteristic of addiction. Addicts typically report fluctuating desires and resolutions, alongside vacillating hope and despair, which lends a sense of psychological reality to hyperbolic discounting models. Moreover, the success of contingency management treatment testifies to the role of discounting in explaining drug choices. It is remarkable that a small amount of money or a prize can provide sufficient incentive for addicts to forgo drugs, when the harrowing consequences of their addiction do not. However, the money or prize is directly and reliably available upon the delivery of a clean urine sample, on a fixed thrice-weekly schedule. There is no significant delay in gratification, and there is no significant uncertainty as to delivery. In comparison, the rewards consequent upon abstinence are not only temporally delayed, but also, for many addicts, extremely uncertain.

Unlike contingency management treatment rewards, the good life does not spring forth readymade simply because an addict quits. There may be long-term physical and mental health problems which cannot be fixed simply through forgoing drugs. Equally, ruined relationships do not just snap back into shape, communities do not quickly forget, and jobs that were lost are not automatically regained. For those addicts who come from underprivileged backgrounds of poor opportunity, housing, education, and employment opportunities do not simply materialize overnight. The creation of a life worth living requires work, and, for many addicts, the cards are stacked against them even if they kick their addiction.

Moreover, for addicts with complex needs, a "suicide option" may function to rationalize the discounting of any possible future reward consequent on a drug-free life, given the cost of abstinence in the present. The option of committing suicide can be very important to people who live with long-term psychological distress, because it offers an escape that lies within their control if life becomes unbearable (Pickard 2015). In so far as drugs offer relief from suffering, the cost of abstinence is very high unless and until alternative means of coping are available: the person must bear not only withdrawal and other drug-related effects of abstinence, but also the psychological distress which the drugs were functioning to ameliorate. If an addict is committed to the option of committing suicide if life becomes unbearable, then it is not obviously worth suffering through abstinence now, because if it is unbearable they will take the option, ensuring that there is no possible future reward for suffering in the present.

Discounting models can explain why addicts choose to use despite the harrowing consequences, whether or not the rates of discounting indicate an impairment: the explanation depends simply on the fact that, at the moment of choice, present rewards are preferred to future rewards. But it is an open question as to whether, given the life circumstances and options realistically available to many addicts, it is irrational to employ a narrow temporal horizon.

2.4 Addiction and knowledge of negative consequences

These three options explain why addicts choose to continue to use drugs even though they know that doing so has negative consequences. Lastly, some addicts may choose to use because they *do not know* that use has such consequences.

To make this vivid, consider as an initial example nicotine addiction during the period of US history prior to the discovery that smoking causes disease, when some people may have guessed, but nobody knew, that cigarettes were bad for you. Indeed, some people may have believed that cigarettes were good for you, due to misleading advertising and government lobbying by the industry (Kruger 1996). Of course, during this period, smoking in fact caused disease. But given that people enjoyed smoking, there is no puzzle as to why they did it despite these negative health consequences, *as they did not know about them.*

From a clinical perspective, smokers during this period could, of course, be diagnosed with a disorder, in so far as they developed tolerance, suffered withdrawal, and experienced cravings and a sense of compulsion. But, given the general availability and acceptance of smoking within US culture, together with the nature of the effects of nicotine, they are unlikely to have neglected other pleasures and activities; or to have experienced any non-health-related serious negative consequences due to tobacco use; and, as they were unaware of health-related consequences, they did not persist in using despite knowledge or clear evidence that use was a problem, and would have been unlikely to have tried to quit at all, and so therefore would have been unlikely to have tried and failed. From a biological perspective, we can of course wonder how any species can have evolved and survived with such a strong *penchant* for things that are bad for them as appears to be the case with us.[6] But if we adopt the perspective of cognitive science and our folk psychological conception of ourselves, addiction only appears to be *a disorder* or to indicate that something is *impaired or wrong* with an individual if they *know or should know*, relative to the cognitive capacities that are standard in the species and the information available to them as an individual, that their drug use has harrowing consequences and yet persist in using.[7]

So, if you're an addict, how do you know that you have a drug problem? One way or another, you have *to discover* that you do. The fact that one's drug use is causing negative consequences is not immediately manifest through introspection, but requires acquiring *causal knowledge*.

There are at least two kinds of causal knowledge, typically acquired by two corresponding routes. On the one hand, there are large-scale generalizations, such as the knowledge that smoking causes disease. Acquiring knowledge of large-scale generalizations typically depends on equally large-scale collective research efforts involving data collection and hypothesis testing and confirmation. For example, the causal link

[6] For an evolutionary perspective on addiction, see Nesse and Berridge (1997); Hagen et al. (2013).

[7] The implications of this claim for the interpretation of animal models and the construct of addiction are discussed in section 4.

between smoking and disease was established by extensive longitudinal comparisons of smoking versus non-smoking populations, and confirmatory evidence from animal models. Once such large-scale generalizations are known in the research community, they can become known to the public at large via the dissemination of expert testimony through channels such as the media and public education initiatives. Crucially, as individuals, we do not have the ability to acquire knowledge of these large-scale generalizations on our own, simply by considering our own experience, but must rely on scientific discovery and its dissemination. But once disseminated, this knowledge is then available for use in individual decision-making. The large-scale generalization that smoking causes disease allows individuals to infer that, if they smoke heavily, then they are at risk of smoking-related disease.

On the other hand, there are small-scale individual generalizations, pertaining especially to our actions and their outcomes. We can often acquire this knowledge on the basis of our own experience alone. If we observe an association between two events—such as an action and an outcome—we can test the possibility of a causal relation by intervening and manipulating the hypothesized cause while monitoring the effect of doing so. For example, although we cannot discover that smoking causes disease on our own, we can potentially discover that, in our own case, smoking causes headache. We can do this by first noticing the association and then testing the hypothesis by controlling our actions: smoke a cigarette, then observe the effects; don't smoke, then observe the effects. Once this causal knowledge is acquired, it can be used in individual decision-making, allowing us to achieve outcomes by means of interventions such as our own actions. So, armed with the knowledge that, in one's own case, smoking causes headache, one can choose not to smoke, so as to avoid headache.

Causal knowledge of the negative consequences of drug use can be difficult to acquire. With respect to large-scale generalizations such as health risks, individuals are not only dependent on scientific discovery and dissemination, but must also be willing to trust the testimony available, as well as to understand and assess probabilities and risk. With respect to small-scale individual generalizations, one's experience may not offer clear confirmation. Given that the causal network of relations is likely complicated and thickly interwoven, and drugs may well be contributory as opposed to single causes, interventions and manipulations may not yield knowledge. As noted above, when addicts quit using drugs, their problems, including those which were initially caused or exacerbated by drug use, do not simply disappear. Indeed, things may get worse before they get better, as they struggle to abstain and live without drugs. So an intervention—forgoing drugs—may not produce the effect—the disappearance of negative consequences of use—which would support the acquisition of knowledge of a causal relationship between them. To take a well-worn kind of example (cf. Segal 2013): if a person's drinking is contributing to ruining their marriage, but they are drinking in part because they are unhappy in their marriage, then stopping drinking will neither immediately fix the marriage, nor correspondingly offer clear evidence that drinking is a cause of the problem. In other words, acquiring causal knowledge of the negative consequences of drug use should be seen as *an*

achievement. It can be hard to come by, and the evidence supporting it may be equivocal. Perhaps it is no surprise, then, if it is also a form of knowledge particularly open to *denial*.

Denial has received surprisingly little attention in the philosophical and scientific literature.[8] Within 12-step programmes it is more central, understood as the unwarranted belief that one can moderate use. Addicts may cling to such a belief, perhaps to avoid facing complete abstinence. But there is only reason to moderate or give up using *if* it is the cause of negative consequences. And denial can equally be directed at this causal knowledge. Consider, as an example, the following first-person report:

> When I was about 8 I developed a keen desire to take drugs. This was in the 1960s, so drugs were all over the media, movies, news reports etc. I started on solvents aged about 11, moved on to various drugs at 14, took them until 20, when I switched to alcohol. I then drank too much more or less every day. I did not until the age of 42 admit that I might be taking any serious risks at all with my health. [But] my denial set in before I had even tried a drug or a drink. Rock stars would appear on TV and say "Don't do this! I tried it and it wrecked my life" sort of thing. Didn't bother me. Yet I was not a particularly foolhardy kid. I didn't take abnormal risks in other areas. But I flew straight into drugs, and into hard drugs. Not shooting up, but anything short of that, cocaine and speed at 15 years of age, without a thought of risk. So what was going on in me at 8, 9 years of age? There may have been a very strong desire to escape reality … which motivated both taking drugs to escape and denial itself … denial being an escape from reality.
>
> (Anonymous addict, personal communication)

Denial pushes knowledge of the harrowing consequences of drug use to the side, thereby serving to explain how addicts choose to continue to use. Even when there is clear evidence, whether available through testimony or through experience, which should provide knowledge and correspondingly incentive to abstain, addicts deny it, thereby removing the incentive. With respect to large-scale generalizations, they may distrust the testimony or, as in the above first-person report, deny that these apply in their case, suggesting belief in a sort of personal exceptionalism, or, perhaps, omnipotence. With respect to small-scale individual generalizations, they may deny the causal consequences of drug use *tout court*: for example, they deny the impact of drinking on their marriage, despite its obviousness to others.

The question this explanation raises, of course, is how it is possible to be in denial, given the testimonial or experiential evidence available. How can addicts *not know* what is staring them in the face? From a folk-psychological perspective, the natural suggestion, of course, is that *they don't want to know*. They don't want to know because they want to continue to use drugs—whether that is because of the strength of their motivation or craving (cf. Robinson and Berridge 2008; Segal 2013); the pleasure of using (Foddy and Savulescu 2006, 2010); the immediate functional value of drugs in their present circumstances (Pickard 2012); or some other reason. Perhaps, too, they don't want to know because of the shame such knowledge typically brings (Flanagan 2013). The key point

[8] There are exceptions: Crowther (Chapter 5, this volume), Flanagan (2011) and Segal (2013, Chapter 20, this volume); cf. too Moeller and Goldstein (2014, Chapter 11, this volume), who propose a self-awareness impairment in addiction which may connect to some forms of denial. The nature of denial in addiction is further explored in Pickard (2016).

is that, according to this suggestion, denial is a drug-related species of more standard forms of epistemically irrational belief, such as self-deception, motivated or biased belief, or outright delusion. We do not at present have a clear and agreed understanding of any of these phenomena individually, or the connections between them.[9] Equally, there are questions about whether people who suffer from these irrational beliefs at least sometimes *do know*, in some sense, or at some level, whatever truth they also at one and the same time deny.[10] The point we wish to emphasize here is that an understanding of this broad set of phenomena may also throw light on addiction, in so far as denial is central to why some addicts continue to use despite negative consequences.

As we saw above, lack of knowledge that drug use has negative consequences need not indicate irrationality, if such knowledge is either straightforwardly not available or the evidence presents a complicated picture. In cases of denial, however, it is epistemically irrational. The evidence is overwhelming that drug use is destroying one's life, and yet one does not believe it. If this is right, then rather than a disease of compulsion, addiction may be a disorder of cognition. What is *impaired or wrong* with at least some addicts is that, as Segal (2013) has vividly put it, they are *insane*: given the evidence, *they should know* that their drug use has harrowing consequences, but they persist in believing it doesn't.

These four explanations are not mutually exclusive. Different explanations, combining different factors, may be true of different addicts. But with this broad picture in view, we now turn to recent studies on the nature of drug choice in addicted rats. Strikingly, these studies in many ways mirror drug choice in humans. In particular, we suggest that they help illuminate the role of ignorance of the negative consequences of addiction in explaining patterns of drug choice that are both destructive and do not reflect the individual's actual preferences. In other words, they help illuminate the core and insufficiently appreciated role played by denial.

3 Ignorance of negative consequences explains self-destructive patterns of drug choices in rats

Rats are the most common non-human animals used in experimental addiction research (Ahmed 2012). They share with us important behavioral and neurobiological traits, including liking and wanting many addictive substances (Nesse and Berridge 1997; Panksepp and Biven 2012; Siegel 1989), but there are also important differences (Suddendorf 2013). Notably, unlike humans, rats have a poorly developed prefrontal cortex—a brain region critically involved in foresight, planning, and decision-making—and limited ability to know the consequences of their own choices (Ahmed 2005, 2008).

Obviously, knowledge of large-scale generalizations is inaccessible to rats as a species. However, less trivially, and in striking contrast to humans, rats are also limited in their

[9] For discussion see Bayne and Fernandez (2009); Bortolotti (2010); Mele (2001); Pickard (2016).

[10] This description may be especially apt when addicts who have been abstinent relapse. For discussion, see Crowther (Chapter 5, this volume); Pickard (2016).

ability to learn small-scale individual generalizations from their own experience about the negative consequences of use. Above, we gave the example of knowing that smoking causes headache, but we can easily multiply this example: there are countless situations where non-addicted human users abstain from taking a drug because they have learned from experience that using brings unwanted consequences. For instance, occasional alcohol drinkers may come to know from experience (and not simply via collective wisdom and testimony) that drinking excessively at night causes a hangover in the morning, impacting on the capacity to fulfill social and occupational roles. Based on this knowledge, they may opt not to drink excessively during the working week, thereby avoiding these negative consequences. In contrast, rats are oblivious to the negative consequences of drug choices. This ignorance explains why, in certain conditions, rats are vulnerable to developing patterns of drug use that cause harm and even death. In other words, rats provide a "proof-of-concept" that continued drug use despite harrowing consequences can be explained by lack of causal knowledge.

Before proceeding, it is helpful to summarize what is known about the factors influencing drug choices in rats. First, when provided with ready access to a drug for self-administration, and without access to alternative rewarding options, most rats will self-administer most drugs that can lead to addiction in humans, including cocaine, heroin, or methamphetamine. They will also escalate their drug use if given sufficient daily availability (Ahmed and Koob 1998) and, as a result, eventually exhibit behavioral changes resembling some of the diagnostic criteria of addiction (Ahmed 2012). For instance, once their use of cocaine has escalated, most rats will expend more time, effort, and cost to gain access to the drug (Ahmed 2012). Finally, post-escalation, most rats will also become more responsive to drug-primed reinstatement of drug seeking after extinction, a widely studied model of drug craving (Shaham et al. 2003).

Second, even after escalation of cocaine use, rats nevertheless retain the ability to quit or reduce intake when offered a valuable non-drug alternative (Ahmed 2005, 2010, 2012). This is particularly well illustrated in a series of experiments where rats were given a choice between pressing a lever to self-administer cocaine or a different lever to drink water sweetened with saccharin—a potent, albeit non-essential for survival, non-drug option. An equal level of effort was required on both levers and choice was either/or to incite rats to express their preferences. Choice trials were also sufficiently spaced in time to measure preferences while rats were not under the influence of drugs. Faced with this choice, most rats quit or reduce their use of cocaine in favour of sweet water (Ahmed 2005, 2010, 2012). Preference for sweet water is observed even after escalation of cocaine use and development of a robust sensitization. Perhaps more surprisingly, preference for sweet water cannot be surmounted by maximally increasing the dose of cocaine. Sweet-water preferring rats only shift their choice to cocaine when the concentration of sweet water is very low, or when the effort required to obtain it is very high. Overall, these findings demonstrate that, even after escalation of use, rats retain the ability to forgo cocaine when offered an immediate and preferred alternative pursuit.

However, third, at first glance, these findings conflict with other seminal research on rats (Bozarth and Wise 1985; Dworkin et al. 1995; Fitch and Roberts 1993). In these studies, rats were given unlimited daily access to cocaine during several weeks in their home cage-environment, where they also had unlimited access to food and water. Most rats consumed cocaine almost exclusively, and eventually to the point of death (presumably caused by starvation, dehydration, and exhaustion).

There is therefore a puzzle with respect to how to resolve the findings of these two series of experiments. In one series of experiments, rats quit cocaine for another reward that had no immediate survival value; while in another series of experiments, rats continued to take cocaine despite fatal consequences. It is by attempting to resolve this apparent discrepancy that the importance of the fact that rats are oblivious of the negative consequences of their own drug choices on other important (and indeed preferred) behaviors becomes apparent.

Consider more fully a detail of the experimental procedure that was only briefly alluded to above. In the studies where the rats quit cocaine for sweet water, choice trials were sufficiently spaced in time for the direct anorexic effects of cocaine on motivation to consume sweet reward to be avoided. In contrast, no such precaution was taken in the studies where the rats continued to take cocaine to the exclusion of food and water. Thus, in the latter series of studies, nothing prevented the anorexic effects of an initial cocaine choice spilling over to subsequent choices and motivationally biasing the rats against their normally preferred sweet reward, and in favour of more cocaine use. Put differently, the first series of studies used a setting where choosing under the anorexic influence of cocaine was prohibited, while the other series of studies used a setting that allowed this influence.

This difference in choice setting can in principle explain the discrepancy in findings. To directly confirm this hypothesis, the same rats were tested in these two different choice settings (Vandaele et al. 2016). As expected, in the setting where choosing under the anorexic influence of cocaine was prohibited, virtually all rats largely preferred sweet water over cocaine, and quit cocaine. In contrast, when the same rats were shifted to the setting where choosing under the anorexic influence of cocaine was possible, their choices shifted from sweet reward almost exclusively to cocaine after only the first few cocaine choices. This shift to exclusive cocaine choices was even observed in hungry rats offered a nutritive sweet solution containing sugar. This shift was not due to mere satiation for sweet water or to a direct behavioral competition or conflict between operant responding for cocaine and operant responding for sweet water. Finally and strikingly, note that this shift to exclusive drug use was not seen in rats tested in the same choice setting but offered heroin which, unlike cocaine, has no anorexic effects (Vandaele et al. 2016).

Thus, once rats make an initial cocaine choice in a setting where choosing under the anorexic influence of cocaine is possible, it is as if they enter a locked-in pattern of exclusive drug choices from which they seem unable to escape, even after several hours. In such a setting, the anorexic effects of a cocaine choice automatically spill over to subsequent

choices, creating a motivational bias against sweet water—a pattern which is then endlessly repeated.

Importantly, rats are not only unable to escape from this locked-in pattern once in it, but are also unable to learn to avoid it through experience by refraining from making an initial cocaine choice. With repeated testing, the pattern persists, despite the fact that it leads to suppression of consumption of sweet reward, their normally preferred option. In fact, the pattern persists even under optimal learning conditions. Briefly, rats were offered two short periods of access to sweet water per session: directly before and after cocaine self-administration. In theory, by comparing sweet water consumption during these two periods of access, an animal should eventually learn to associate cocaine self-administration with suppression of sweet reward and thus refrain from initiating or at least reduce cocaine self-administration. However, this did not happen. Although cocaine self-administration repeatedly suppressed sweet water consumption during the second period of access, rats nevertheless continued to self-administer cocaine (Vandaele et al. 2016).

In sum, rats behave as if they are oblivious to the anorexic influence of their own cocaine choices on other competing activities. The origin of this "irrational" behavior requires further study, but presumably reflects rats' limited ability to know the consequences of their own choices: to foresee the negative influence that taking a drug now will have on other competing, even preferred behaviors, in the near future.

To be clear, we do not deny that rats can learn to associate drug taking with some *immediate* negative consequences. They clearly can (Krasnova et al. 2014; Panlilio et al. 2003). For instance, rats will eventually stop pressing a lever to self-administer a drug if immediately punished with a sufficiently high-intensity painful event, such as a foot-shock. Similarly, we do not deny that rats can pursue a short-term goal, taking the immediate consequences of their choices and anticipated events into account (Dickinson and Balleine 1994). However, the time horizon in all known instances where they display this capacity never exceeds a few seconds. This is too narrow a horizon to encompass the influence of drug taking on other competing behaviors, which are more significantly delayed in time (cf. Roberts 2002; Suddendorf and Corballis 2007).

Rats' ignorance of the influence of drug taking on other competing behaviors makes them vulnerable to harm themselves in certain choice settings. As explained, this occurs when they are given unlimited access to cocaine for self-administration in their home cage environment, where they also have unlimited access to food and water (Bozarth and Wise 1985; Dworkin et al. 1995; Fitch and Roberts 1993). Most rats self-administer cocaine to the exclusion of food and water, and eventually die within three weeks. The only way to protect rats from developing this pattern of exclusive drug choices seems to be through an outside intervention aimed at restructuring the choice setting to prevent choices being made under the influence of the drug.

Rats' behavior illustrates how a lack of knowledge can drive continued drug use despite harrowing consequences. Because rats *cannot know* that drug use carries such consequences, they do not even attempt to discontinue use. They continue to use despite the fact that doing so means they forgo the reward which, given a forced choice, they prefer

to drugs—and, even more, despite the fact that, given the biological importance of the forgone reward to survival, they eventually die.

4 From rats to humans: the role of knowledge of negative consequences in understanding addiction

Rats *cannot* come to know on the basis of their experience that their drug use causes negative consequences, given their limited cognitive capacities. Human addicts, in contrast, *can* know this when there is sufficient evidence—whether testimonial or experiential. Rats therefore represent what we might think of as a maximally idealized case of denial. When in deep denial, we can understand human addicts as locked in to a pattern of drug use despite negative consequences, similarly to rats. Hence one lesson from rat models of addiction points, paradoxically, to the importance of capitalizing in developing treatment on the human capacity that is precisely lacking in rats, namely, the capacity for knowledge that drug use is causing harrowing consequences.

It is important to acknowledge that many effective forms of treatment do not capitalize on this capacity, but rather aim to restructure human addicts' choice settings, e.g. contingency management treatment, or environmental restructuring to avoid drug-related triggers and cues. Arguably, we can also see social, education, and employment initiatives designed to provide better life opportunities to addicts in a similar light as aiming to compete with or crowd out drug choices. The value and importance of these various forms of intervention is unquestionable. But humans also have an additional resource to help overcome addiction: the capacity to know the negative consequences of drug use and to use this knowledge in making drug choices. Some forms of intervention already capitalize on this. Public education initiatives aim to disseminate large-scale general knowledge of the risks surrounding drug use. Motivational interviewing, some forms of counselling, and 12-step programmes alike aim to help addicts recognize and face the small-scale individual consequences of drug use, to motivate change. Indeed, there is evidence that many addicts who quit do so after an "awakening" process, which may be slow and erratic, but which eventually culminates in recognition of the impact of drug use on their lives (cf. Raab and Brown 2010). However, there is an urgent need to better understand the nature, mechanisms, and ways to overcome the various kinds and degrees of denial present in human addiction, to develop effective interventions targeting denial and appropriate to different phases of the trajectory toward addiction. We should not cleave to the myth that addicts must hit "rock bottom" before they are able to overcome denial.

However, a second lesson from rat models, equally paradoxical, is that it is unclear whether or not rats *can be addicted at all*. Put otherwise, comparing rats and humans reveals that there is an ambiguity inherent in the current construct of addiction.

The ambiguity concerns whether or not addiction involves drug use *despite negative consequences* (as the orthodox conception of addiction suggests) or drug use despite *knowledge or sufficient evidence* of negative consequences (as the diagnostic criteria employed in the DSM-5 and the ICD-10 suggest). On the former understanding, rats

can be addicted, as evidenced in settings where they choose to use cocaine to the point of death. However, if this is how to understand addiction, then it is unclear why addiction is *a disorder*. For, as we stressed above, it is only if an individual *knows or should know*, relative to the cognitive capacities that are standard in their species and the information available to them as an individual, that their drug use has harrowing consequences and yet persists in using, that there is reason to think anything is *impaired or wrong with them*. If rats cannot know, given the cognitive limitations of their species, that the choice to take cocaine will influence future choices, causing them to forgo rewards which they prefer to cocaine and which are necessary to survival, then it is hard to argue that anything is disordered or impaired in their choice. They both like and want cocaine, so they take it, ignorant of the consequences of this choice due to species-limitations, and hence through no individual impairment due to drug use. On the other hand, on the latter understanding, whereby addiction involves drug use despite *knowledge or sufficient evidence* of negative consequences, addiction is clearly a disorder, but rats cannot be addicted despite their propensity to use drugs to the point of death. For, given their species limitations, they do not use drugs despite *knowledge or sufficient evidence of* negative consequences, for they have none.

We do not propose to answer this question about the construct of addiction here, but rather simply to raise it as one of the new puzzles to emerge out of choice models of addiction. The evidence is very strong that addiction involves choice, and we hope to have made progress toward properly addressing the question of why, given the harrowing consequences of drug use, addicts persist in using when they could instead abstain. The first three explanations we sketched appeal to how addicts may represent and weigh the costs and benefits of use; the fourth explanation appeals to denial and the point that, if one doesn't know that an action brings with it costs, then one will not weigh those costs in choosing whether or not to act. According to this explanation, human addicts who are in denial are epistemically irrational—subject less to a disease of compulsion than a disorder of cognition. They should know their drug use is having a harrowing impact, but they do not. But to be epistemically irrational requires an individual to have the capacity to be epistemically rational. Whether or not this is central to the construct of addiction is an issue calling out for further research.[11]

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