Avinash Dindial

1006020949

PSY 312 final essay

A predictive processing account of addiction

Abstract

It can be argued that addiction is one of the most stigmatized diseases of the 21st century. Addicts are often portrayed as irrational persons who fail to maximize future rewards; despite heavy costs, they seem to prefer to engage in drug-seeking behavior over more rewarding courses of action (Ahmed, 2004). I do not limit the word addiction to mean simply drug addiction although I will be highlighting this much more since it is the most prevalent but rather people can be addicted to behaviors such as gambling. The main concept people have of addiction is that the core of addiction is satisfying your body's craving for something. Most people focus on this biological account for addiction. That is, after time, the body requires a substance or chemical in order to function, lack of which can result in sometimes serious withdrawal effects. This physical way of looking at addiction states that the brain rewires itself in such a way that it prioritizes seeking the stimuli to satisfy cravings. However, this cannot be the entire account of addiction as there must be cognitive mechanisms behind this behaviour and understanding these may help us understand this disease much better. The predictive processing account of cognition is becoming increasingly popular, and I will be using this as a base on how we can explain addiction in the mind. In predictive processing, we use feedback loops to minimize errors and better predict the world and reduce surprise.

It is the goal of this paper to use this predictive processing model of the brain to show that addiction is not just physiological but rather addiction is the environment in which they create for themselves which maximises comfort and minimizes surprise.

Introduction

Addiction brings chaos to those who are unfortunate enough to be affected by it, giving it good reason for being thoroughly understood. Often, addicts will engage in destructive behavior to meet the needs of their addiction. There is a curious relationship the addict has with their stimuli of choice in that they would do anything to access it but at the same time they want to stop engaging in these behaviors. This leads to a destructive loop of feeling powerless to fight an addiction and retreat to the comfort that it brings. The brain disease model of addiction has yielded effective preventive measures and treatment interventions (Volkow et. al., 2016). Neuroscientists support the idea that addiction is a brain disease which they support with empirical evidence in changes in brain architecture etc. There is a philosophical debate on justice that can be raised on addiction: If it is a disease, do we punish those who act on impulses driven by this disease? Some addicts turn to crime such as petty theft in order to get money to feed their addiction. It is common for people to blame these addicts for their illegal behavior and for them to take responsibility and disregard addiction as a viable reason for engaging in these activites. While I disagree with the methods in which some feed their habit, I do not agree that they should be demonized. Society has a preconceived notion of addiction that it is something a person can easily control and saying it is a disease is taking away responsibility from that person and excuses their behavior. One can also argue that addiction cannot simply be a disease since recovery is possible without intervention or treatment (Volkow et. al., 2016). There is a lot of opposing views on this topic so in this paper, I will attempt to present the best argument as to what addiction really is drawing from both empirical and theoretical evidence.

Now that we understand the general gist of addiction and the implications it brings, I can now introduce the mechanism in the brain that drives addiction: predictive processing (PP). This states that organisms do not merely respond to stimuli but proactively model and predict sensory inputs and the opportunities and challenges they represent (Van de Cruys et. al., 2021). The underlying goal of PP is to anticipate the world and thereby reducing surprise i.e., reducing prediction error. The brain reduces errors in two ways: Assimilation and accommodation. Assimilation is altering new information, so it fits the existing model while accommodation is changing the current model to fit new information. When a dynamical system undergoes these processes in parallel, we get complexification whereby the system models itself and the environment. The PP framework hence entails that a person's behavior is canalized by the ways in which they construe and anticipate events and their own reactions to these (constructed) events (Kelly, 1970). We can see the recursive feature of this framework. What can be harmful about addiction is the build-up of error over time, and a failure to adequately assign precision to relevant affordances in the addict's dealings with a dynamic, and volatile world (Miller et. al., 2019). So, in addiction, it is proposed that there is recursion of errors in the brain that builds a false model of the world. Crucially, persistent prediction errors in reaching desired action outcomes can lead to model updates that increase the expected uncertainty or simply put, the perceived powerlessness of actions (Van de Cruys et. al., 2021), which is seen in addiction. In the following pages, I will attempt to show how PP shapes the world of an addict by making them fit a false model of themselves and the environment.

Predictive processing theory uses Bayesian probability as a way in which we can anticipate the world. It is an attractive framework because we think it can formalize the tendency toward an optimal grip in terms of the dynamical coupling between brain dynamics and the dynamics of the

whole brain-body-environment system (Bruineberg et. al., 2014). Optimal grip refers to the best trade off relationship between a Gestalt and its features such that is appropriately describes the world. We are drawn towards opportunities for improving grip, and positive feelings arise when we improve grip at a faster than expected rate (Kiverstein et. al., 2017). Optimal grip can be seen in problem solving where we would need to loop through selection and variation in order to formulate a good problem formulation. There might be some overlap in the mind of an addict as to what is the real world and what is their perceived world, resulting in illusory feedback. This makes the addict comfortable in the environment they created, centered around a substance, blissfully unaware of the world around them (ignoring finances, family etc.). This comfort can be explained by the brains way of reducing surprise; it knows that a good feeling would come upon attaining a certain stimulus, so there is no surprise whatsoever. The brain disease model of addiction is questionable since the irrational and compulsive behavior characteristic of addiction cannot be explained by neurobiology (Volkow et. al., 2016).

PP starts from expectations, and not from rewards, as the causes of behaviour. Agents act to minimise surprise about their own future sensory states (Miller et. al., 2019). Agents refer to organisms that are autopoietic, adaptive, and autonomous. Recall predictive processing is defined as the multi level, top-down, error reducing processing that constantly generates a model if itself

and the environment. So, higher layers of the model involve more abstract processes than the bottom layers and errors are reduced as these processes are constantly bootstrapped (in the statistical sense of the word) in the upper layers. Surprise, in this paper, refers to any deviation from the expected outcome in the environment. In cognitive agents, including addicts, the brain attempts to minimise surprise. By getting better at reducing surprise, the organism gets better at being able to anticipate the world. In order to do this, the agent must undergo a series of tasks that is most likely to take them to their desired goal. In addicts, the goal is often to get high, or feel happy, or in some cases to avoid withdrawal symptoms. So, to do this, the obvious thing to do to get to the desired state is taking drugs. In substance abuse addicts, the physiological states they come to occupy because of using the substance, are among those they learn to expect (Miller et. al., 2019). The theory outlined by Miller et. al., compares the craving of drugs to hunger. Organisms embody homeostatic states that are required for continued existence but that they can only realize via action in their environment (Van de Cruys et. al., 2021). The need for drugs is seen as a homeostatic state in addicts, and since they are autopoietic agents, they will do whatever necessary to sustain itself. The reorganization of the brain, particularly dopaminergic systems, is not due to a disease of the brain, but rather it is now efficiently adapted to the needs of the addict. Addiction therefore becomes part of that person's identity, so in order to stop using, one must hijack their very own identity which is no small task.

In active inference, such as in PP, precision reflects the degree goal-directedness of behaviour (Shwartenbeck et. al., 2014). As we know, a big part of PP is error reduction. Error in this case refers to the difference in the anticipated vs current sensory states. While all organisms try to reduce error, the difference in addicts is that they rely on drugs which provide a much quicker way of reducing error; they provide instant gratification. If prediction errors have low (expected)

precision, predictive models may overwhelm error signals (hallucination) or elicit actions that confirm sensory predictions (active inference) (Seth, 2014). According to PP, this build up of error is what causes cravings, and is only remedied by succumbing to the pressure and seek out substances or distract themselves if it is not currently available. This can be seen in the uneasiness and tension seen in addicts when they are craving their substance of choice. It is obvious that it 'feels good' when these error predictions are reduced and it 'feels bad' when these errors cannot be reduced. Addictive substances make it appear to the agent as if error is being reduced rapidly at a rate that is faster than anything the agent has anticipated. As soon as the drug wears off, prediction errors begin to increase again (Miller et. al., 2019). This reduction in error only exists in the mind of the user as nothing has changed in the real world. This makes addiction such a deep-rooted disease of the mind, rather than a surface level brain disease. It is not simply craving dopamine, although dopamine plays a critical role, the underlying mechanism of this is due to a build up of errors and the user seeks to quickly reduce these errors. Shwartenbeck et. al., showed that precision is encoded in dopaminergic systems and showed there is an association between impulsive behaviour and dysfunction of dopaminergic systems in addiction (Shwartenbeck et. al., 2014). This empirical evidence fits with the theory of error minimization as agents would seek to reduce errors at the cost of impulsive or sometimes destructive behaviour. Substance abuse leads to the learning of sub-optimal precision expectations (Schwartenbeck et al., 2015). This model explains the impulsivity and lack of self control we see in addicts. They also pointed out the importance of dopamine in weighing precision of relevant actions that is relevant to a person. Dopamine signals the agent's high degree of confidence that its current sensory states will lead to expected future sensory states, those consequent upon drug use (Miller et. al., 2019). Even more empirical evidence points to

addiction as a hyperdopaminergic state leading to over precise predictions and perseverative errors (Kaye et. al., 2020). In line with this evidence, it is argued that the downfall of addicts is the high precision weighted to drug related behaviour (both seeking and taking). This is far from the Pavlovian perspective the reward-based theory of addiction suggests.

Rationality can be defined as the ability to overcome self deception. According to the dual processing theory, rationality is how we coordinate our coping and planning systems. Coping systems are our associational, sensory motor management systems while planning systems are our logical, formal systems. In hybrid systems that use both systems, as in humans, there is sometimes inner conflict between these systems. In the case of addiction, addicts tend to disregard long term goals in favour of short-term goals such as getting high. This is a different theory of processing but still lines up with our theory of addiction in that it is a much deeper issue than purely physiological. We can think of this as a temporal increase, where addicts make drugs more salient as time goes on; the longer they go without it, the more salient it becomes. This theory provides supplementary explanation on how cravings work in addicts, and it is in line with the idea that it is not just physiological. The mainstream idea that cravings are just the brain seeking out reward for taking the drug is insufficient as there are much more mechanisms behind drug seeking behaviour than just seeking reward. Reward is the consequence of behaviour, not it's cause - the agent is rewarded when the future outcomes of its actions are expected or unsurprising (Miller et. al., 2019). We need explanations of how the agent brings this unsurprising state to fruition in order to fully understand the depths of this disease.

Now, we have seen how the addict's brain is now efficiently modelling the environment and itself in such a way that is heavily biased towards feeding their habit. However, this model of the

world addicts build is constraint to feeding their habit and is not suitable for the real world. This may be why addicts seem to act irrationally: neglecting personal responsibilities and relationships, spending all their money on vices etc. In terms of PP, the brain is doing exactly what is should; it is building a good model of the world to sustain itself (Miller et. al., 2019). It is not hindered or 'diseased', rather it is simply adapting to a new model of the world. The disease model of addiction places emphasis on the neurobiological changes in the brain. These changes are profound, and this paper recognizes the importance of the implications of the physical changes in the brain. To clarify, I agree the physiological changes are important in this disease as it can be used as a base for developing medication to help addicts, however it cannot be the whole story behind addiction. Based on five years of ethnographic fieldwork with addiction researchers, clinicians, and patients, empirical realities are not consistent with the disease model of addiction (Dingel et. al., 2012). The downfall of this disease model is that it puts reward learning and dopamine as the mechanism behind addiction, but we have seen it is much more than this simple association. Instead, dopamine is involved in precision weighting (Frinston et. al., 2014). The overarching principle of prediction error minimization means that the mental system is geared toward maximizing the evidence for one's model (Van de Cruys, 2021). One does not need to appeal to rewards in order to explain behavior but can replace them with prediction and anticipation; utility functions are replaced by the minimization of prediction error (Bruineberg et. al., 2014). There are numerous lines of evidence that points to this reward-based theory of addiction being insufficient, albeit important, in explaining behavior and by extension addiction.

I have so far argued that the underlying cause of addiction is hidden in the brain where substances are trusted with guaranteeing a predicable, comfortable reality. Even if it is the exact opposite in the real world, in the mind of an addict, they cannot distinguish their perceived reality constraint to getting high from the actual world. Treatment for this disease therefore cannot be like other bodily diseases. Rather, treatment must incorporate medications to deal with withdrawal and recovery AND psychotherapy/behavioral therapy to enhance salience of natural stimuli as well as reducing error and reorganizing the brain to fit the actual world. In addition, we would need to change their optimal grip on the world by altering an addict's aspect of the world. Aspects are chunks of information that is perceived by us and depends on point of view. This involves perspectival knowing (comprised of salience landscaping) which gives rise to situational awareness and may help in the recovery process as there is a dynamic relationship between substance abuse and the compulsion to deny reality (Barnes, 2013). In conclusion, I have shown how the classic theory of addiction is insufficient by proposing relevant theoretical and empirical literature to show the mechanisms behind addiction. Indeed, we have seen it is much more than simply taking drugs to satisfy cravings or taking more due to increase in tolerance, rather addiction is a disease that quite literally changes the identity or 'self' of a person. This can be seen physically in the brain which goes to show how pervasive this disease gets in the brain. Addiction causes physiological difference due to changes in abstract cognitive mechanisms. Despite the ongoing research, there is much to be done in this field to effectively treat addiction, this time focusing on cognitive mechanisms in addition to physical structures of the brain.

REFERENCES

Allen, M., & Friston, K. J. (2018). From cognitivism to autopoiesis: towards a computational framework for the embodied mind. *Synthese*, *195*(6), 2459-2482.

Bruineberg, J., & Rietveld, E. (2014). Self-organization, free energy minimization, and optimal grip on a field of affordances. *Frontiers in human neuroscience*, *8*, 599.

Cousijn, J., Wiers, R. W., Ridderinkhof, K. R., van den Brink, W., Veltman, D. J., Porrino, L. J., & Goudriaan, A. E. (2013). Individual differences in decision making and reward processing predict changes in cannabis use: a prospective functional magnetic resonance imaging study. *Addiction Biology*, *18*(6), 1013–1023. https://doi.org/10.1111/j.1369-1600.2012.00498.x

Dingel, Hammer, R., Ostergren, J. E., McCormick, J. B., & Koenig, B. A. (2012). Chronic Addiction, Compulsion, and the Empirical Evidence. *AJOB Neuroscience*, *3*(2), 58–59. https://doi.org/10.1080/21507740.2012.665411

Kelly, G. A. (1970). A brief introduction to personal construct theory. *Perspectives in personal construct theory*, *1*, 29.

Khanbabaei, S., Abdollahi, M. H., & Shahgholian, M. (2022). The predictive role of working memory and impulsivity in internet addiction, an investigation about the mediating role of time perception. *Personality and Individual Differences*, *185*, 111280.

Kiverstein, J., Miller, M. & Rietveld, E. The feeling of grip: novelty, error dynamics, and the predictive brain. *Synthese* **196,** 2847–2869 (2019). https://doi.org/10.1007/s11229-017-1583-9

Miller, M., Kiverstein, J., & Rietveld, E. (2020). Embodying addiction: A predictive processing account. *Brain and Cognition*, *138*, 105495–105495. https://doi.org/10.1016/j.bandc.2019.105495

Schultz, W. (2016). Dopamine reward prediction error coding. *Dialogues in clinical neuroscience*, *18*(1), 23.

Seth, A. K. (2014). *The cybernetic Bayesian brain*. Open MIND. Frankfurt am Main: MIND Group.

Van de Cruys, S., & Van Dessel, P. (2021). Mental distress through the prism of predictive processing theory. *Current Opinion in Psychology*, *41*, 107–112. https://doi.org/10.1016/j.copsyc.2021.07.006

Volkow, N. D., Koob, G. F., & McLellan, A. T. (2016). Neurobiologic advances from the brain disease model of addiction. *New England Journal of Medicine*, *374*(4), 363-371.