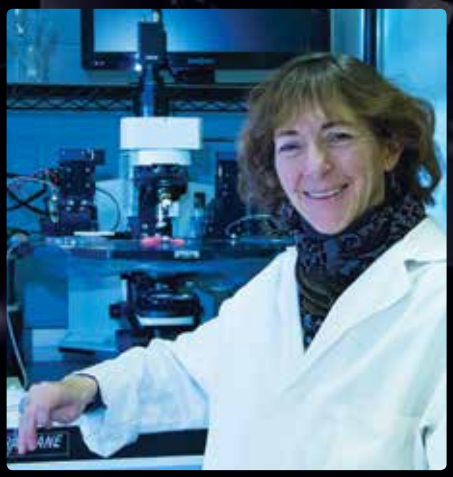
Influenced by impulse

Psychologist **Dr Mary Olmstead** shares details of her work, which attempts to understand impulsive behaviour in drug addiction, and explains how the study of music led her to this research field



What attracted you to the study of cognitive-motivational interactions and how rewarding stimuli influence learning?

I studied music as an undergraduate student and was fascinated by the idea that music elicits such profound emotional responses in people. This is not culturally specific; it happens all over the world – although different types of people obviously prefer different music. This interest led me, indirectly, to psychology, a field that has a long tradition of trying to understand how emotions guide behaviour. Very early in my training, I worked with Dr John Yeomans at the University of Toronto, training rats to press a lever for electrical brain stimulation. It was almost shocking how rapidly and consistently rats would lever press for this stimulation. Although we try to avoid anthropomorphising, it really appeared that they cared about little else! As I continued my research and education in psychology, I started thinking about how these reward signals would interact with other psychological processes, such as learning. We are often taught that emotions have a negative impact on cognition (particularly decision making), but I kept thinking that this couldn't be entirely true. Otherwise, why would we always be attracted to things that made us feel good but want to avoid those that made us feel terrible?

What is recreational drug use, and what are the differences between motivational, cognitive and impulsive behaviour in this context?

Recreational drug use does not usually fit a clinical criterion for addiction – that is, it does not cause severe disruption in social or personal activities. The category may include those who drink alcohol socially for many years, but it could also include new users who are experimenting with drugs but have not yet reached the stage of having the drugs interfere with their daily activities. So, the category is quite heterogeneous. Either way, understanding differences between motivational, cognitive and impulsive behaviours is difficult because what we observe is excessive focus on the drug and an inordinate amount of time and effort devoted to securing it. Motivational factors could be the desire to obtain and consume the drug, cognitive factors could be an understanding of the short- and long-term impact of drug use, and impulsivity may be an inability to control responses to drugs and drug-paired stimuli.

How have your collaborations with individuals such as Professors John Yeomans contributed to the success of your research?

I have had so many wonderful collaborations over my career that it would be almost impossible to determine how each has contributed to my research programme. If I were to isolate one influence, I would note that my early mentors, such as Professor Yeomans, were full of enthusiasm for science in general. He made research sound so fun that it was hard to believe anyone would want to do anything else. Recently, I have been fortunate to establish very productive collaborations at my own institution: one with pharmacologist Dr Catherine Cahill and another with electrophysiologist Dr Éric Dumont.

Could you elaborate on the work you are conducting with Drs Cahill and Dumont?

I share many theoretical interests with both Dr Cahill and Dr Dumont, such as the relationship between reward and cognitive processing, but we have approached these questions from very different perspectives. My research team works primarily with behavioural models that complement both the approaches and techniques available

in the Cahill and Dumont laboratories. For example, Professor Dumont employs electrophysiological techniques to measure synaptic plasticity in rodents. Collaborating with him allowed us to ask questions about the relationship between changes in behaviour (ie. learning to inhibit a motor response) and brain responses (ie. increased strength of synapses connecting neurons in the prefrontal cortex to the ventral striatum). The same general overview has provided a framework for my work with Dr Cahill who is an internationally recognised expert in pharmacological mechanisms of pain, particularly related to the opioid system. Dr Cahill has established a hypothesis linking the neural changes that accompany chronic pain with the development of affective disorders such as anxiety and depression. We are now testing these ideas in our animal models.

Do your students play an important role in your work?

Without a doubt, my students (who are in every sense collaborators) make the greatest contribution to the success of my research. This is not simply because they work so hard! Rather, it is because they always bring new and interesting perspectives to anything I am doing. In many cases, I can trace an idea that has developed in my lab back to an individual student who decided to pursue a particular line of work. And without fail, by the time they leave my lab, they always know far more about their topic than I do!

Just say **know**

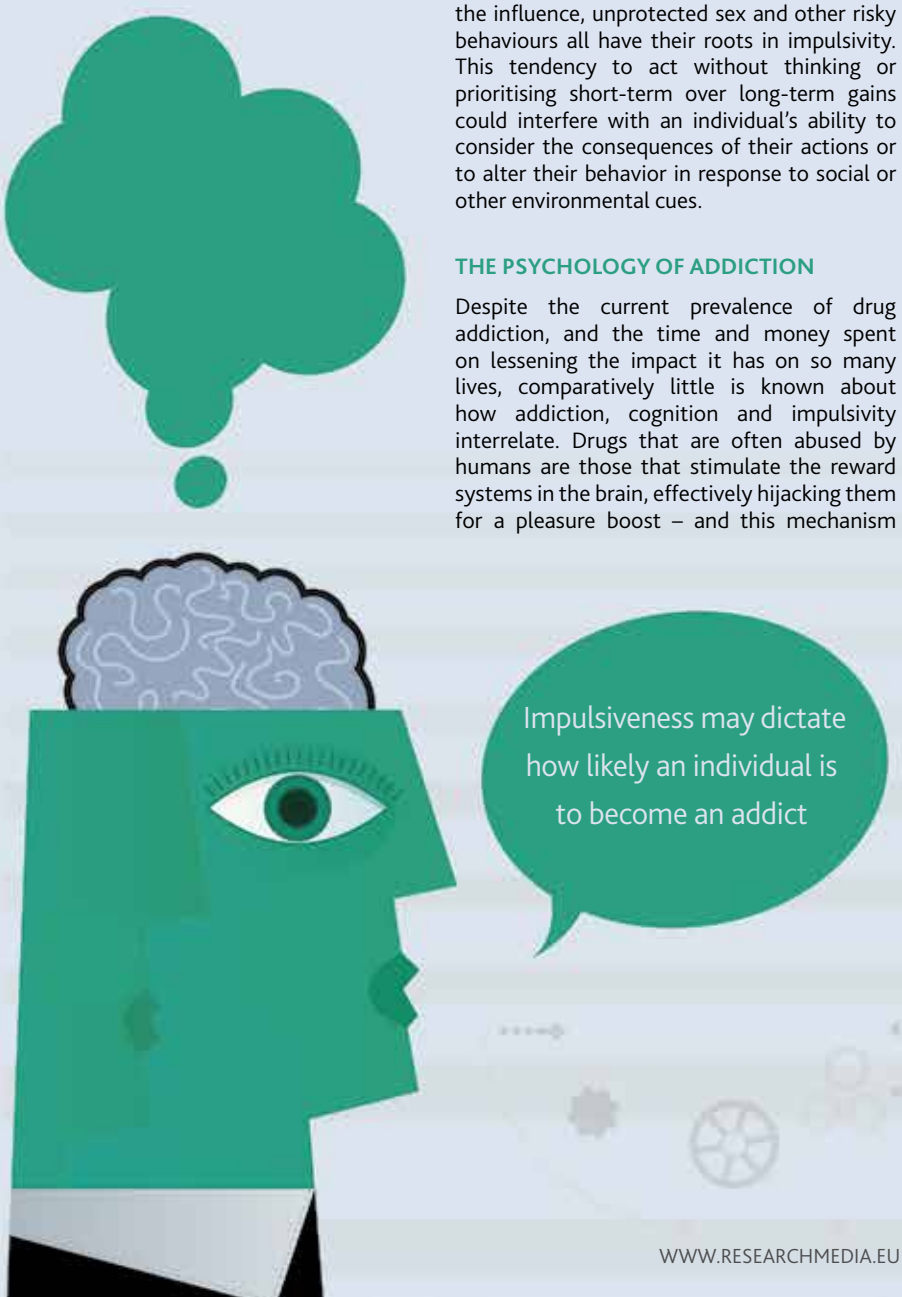
A laboratory at **Queen's University** in Ontario, Canada has been conducting a number of animal and human studies with a view to determining the exact relationship between motivation and cognition – especially in the case of drug addiction

DRUG ADDICTION IS the product of two behavioural traits: drug-seeking or compulsion to take the drug and impulsivity or an inability to limit drug intake. These activities appear similar but subtle differences exist that are important for scientists conducting research into addictive disorders.

Decades of research have helped to uncover the physiological and environmental characteristics that produce compulsive drug-seeking, whereas psychologists have only begun to examine how impulsivity contributes to addiction in the last few years. It is now clear that impulsivity not only defines addiction, but is the trait behind many of the most troubling outcomes of drug use. Driving under the influence, unprotected sex and other risky behaviours all have their roots in impulsivity. This tendency to act without thinking or prioritising short-term over long-term gains could interfere with an individual's ability to consider the consequences of their actions or to alter their behavior in response to social or other environmental cues.

THE PSYCHOLOGY OF ADDICTION

Despite the current prevalence of drug addiction, and the time and money spent on lessening the impact it has on so many lives, comparatively little is known about how addiction, cognition and impulsivity interrelate. Drugs that are often abused by humans are those that stimulate the reward systems in the brain, effectively hijacking them for a pleasure boost – and this mechanism



INTERACTIONS BETWEEN IMPULSIVITY AND REWARD: RELEVANCE TO DRUG ADDICTION

OBJECTIVES

- To understand the neural and psychological interface between motivation and cognition
- To determine how rewarding stimuli influence learning

KEY COLLABORATORS

Dr Éric Dumont, Queen's University, Canada

Dr Catherine Cahill, University of California, Irvine, USA

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MARY C OLMSTEAD completed her BSc at the University of Toronto, majoring in Psychology and Music. Her interest in motivation and how it is controlled by the brain began when she worked with Professor John Yeomans in the Department of Psychology. She then earned an MSc and PhD at McGill University with Professor Keith Franklin where she investigated neural systems of reward-related learning. As a postdoctoral fellow, she worked at the University of Cambridge with Professors Barry Everitt and Trevor Robbins. In 1998, she joined the Department of Psychology at Queen's University where she continued to investigate cognitive-motivational interactions, or how rewarding stimuli influence learning. She spent one year as a visiting scientist at the Institute of Genetics and Molecular and Cellular Biology (IGBMC) in Strasbourg, France.

raises important questions for psychology in broader terms, representing as it does a breakdown of the relationship between motivation and cognition.

This is just one of the concerns being addressed by psychologist Dr Mary Olmstead and her team of researchers at Queen's University in Ontario. Olmstead's research is directed towards understanding how rewarding stimuli influence learning on a neural and psychological level, with particular reference to drug addiction. The interface between motivation and cognition is very complex, but her hypothesis is that goal-directed behaviours and cognitive processes, as part of a dynamic interactive system, reciprocally modulate each other. Her research uses two complementary approaches to investigate this process: firstly, it examines how reward-related learning is manifested in behaviour as part of a theoretical overview of motivation-cognition interaction, and secondly, it examines specific neural systems that might be responsible for mediating the cognitive-motivational interface.

ANIMAL STUDIES

The group has developed a response inhibition task that has proven particularly useful in animal studies. For this task a group of rats is taught to press a lever, releasing a sugar pellet; when they can do so quickly and accurately, the scientists add a waiting period – a light will come on when the waiting period is up, signalling to the rat that it is time to press the lever and receive a pellet. If the rats are impulsive and press the lever without waiting for the signal, they receive nothing, and have to wait before they can try again. The task is beneficial because it can be learnt rapidly, provides measures of individual difference across rats, and can be manipulated in other experiments in order to demonstrate changes in performance under a variety of conditions.

It was this task that allowed the Ontario group to test whether or not impulse control required new learning. In collaboration with Queen's University biomedical scientist Dr Éric Dumont, the psychologists showed that impulsive action is encoded as enhanced glutamate transmission in projections from the prelimbic region of the medial prefrontal cortex to the ventral striatum. A follow-up study revealed increased membrane excitability in the same neurons, providing further support for a specific mechanism underlying the acquisition of impulse control. An unexpected and intriguing outcome of this study was that plasticity in the adjacent infralimbic cortex encodes learning about cues predicting reward availability – suggesting that there may be a functional dissociation across the infra- and prelimbic cortices in the control of impulsive action.

In another important animal research project, this time carried out in collaboration with Dr Brigitte Kieffer's team at the Institute of Genetics and Molecular and Cellular Biology (IGBMC) in France, the Ontario lab showed the first evidence for an opioid contribution to impulsive action. The researchers found that deletion of δ-opioid receptors increased impulsive action, whereas deletion of μ-opioid receptors had the opposite effect – but when they subsequently tested whether opioid drugs alter impulsive behaviour in rats, they found that the data from the two studies were inconsistent. This discrepancy led the team to suspect, and then confirm, that inhibition of a motor response is controlled by different cognitive processes, depending on the demands of the task. They are now working to determine whether differences in inhibitory cognitive processes could explain individual differences in trait impulsivity.

STUDENT SUBJECTS

In addition to working with animal models, the Ontario psychologists are pursuing a complementary line of research translating this work to humans. University students exhibit high rates of drug use and risky behaviour, and are highly vulnerable to addiction and mental illness because of a number of social and environmental factors. Some of the results that the psychologists have produced working with students have been unsurprising: hormonal and subjective stress levels are reduced by alcohol, initial levels of stress correlate with the physical effects of alcohol, and self-reported impulsivity correlates with recreational drug use and hazardous drinking. What is interesting, however, is the revelation that alcohol intoxication does not increase risky choices in a gambling task, or impair reward-related learning; in fact, hazardous drinking enhanced conditioning to reward-paired cues. Even more surprising, an alcohol placebo drink caused the same reduction in anxiety as alcohol, suggesting that just believing that one was to receive alcohol was enough to reduce stress.

This work demonstrates, not for the first time, that both animals and humans exhibit individual differences in impulsive tendencies. These traits are based on inherited as well as learnt characteristics. In other words, it might be possible to 'learn' to be less impulsive and, in cases of drug addiction, this has the potential to be a useful form of intervention treatment. Another possibility, which the Ontario team is investigating, particularly with regard to its human studies on university students, is that certain characteristics such as impulsiveness may dictate how likely an individual is to become an addict. If it were possible to gauge an individual's 'risk' from their personality traits, then this information might be of use to universities in ensuring student welfare – or, ultimately, to healthcare professionals.