

**FORESIGHT**

Drugs Futures 2025?

Horizon Scan

OFFICE OF SCIENCE AND TECHNOLOGY

While the Office of Science and Technology commissioned this report, the views are those of the authors, are independent of Government and do not constitute government policy.

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# Introduction

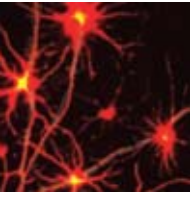
This report from the Foresight project on Brain Science, Addiction and Drugs contains the detailed Horizon Scan produced by the project's science experts, Prof David Nutt, Prof Trevor Robbins and Prof Gerry Stimson.

It has been written with the benefit of the state-of-the-science reviews commissioned by Foresight from world experts in the many fields of interest to the future of brain science, addiction and drugs. These range from sociology, social policy and economics to neuroscience and drug treatment. It is not a précis of the reviews, of which two-page summary versions are available. A list of the review titles is at the back of this document.

This Horizon Scan articulates Foresight's objective of providing Government and others with challenging visions of possible futures. It is based on scientific evidence of the state of play at the time of writing (September 2004 to May 2005), and builds on this evidence base to look at possible future change. It does not offer predictions, but it does raise issues and possibilities that policy makers and others might wish to consider. Some are more speculative than others. As this report looks out to 2025 and future possibilities, it inevitably challenges current thinking.

There are certain to be significant advances in science in the coming 20 years, the timescale of this project. They will come from a variety of converging directions, including our increased knowledge of the human genome and its expression; drug effects on the brain; the nature of addiction including its development; factors involved in resolution and relapse; and a range of effective treatments. Our knowledge of the motivation behind addictive behaviour may have applications for treatment of behavioural addictions, as well as substance addictions.

Less certain are the new drugs that may emerge for purposes such as medical treatment, pleasure and cognitive enhancement. These uses are likely to overlap. A drug that is used to treat identifiable medical conditions, for example, Alzheimer's disease, may also attract those within the normal range of performance who hope to enhance their mental powers. It is likely that the pharmaceutical industry will find it uneconomical to develop drugs to match all the potential targets that science will discover. This possibility exists alongside that of the medicalisation of behaviour and of conditions that are regarded as normal today.



Another area of uncertainty is the future prevalence of problem drug use and its costs, including healthcare and the social costs of crime and of disrupted work and family lives. Nor do we know how society will view the use of psychoactive substances in 20 years. While it is possible that such use will be more widespread and accepted, there may be a backlash against it in some parts of society.

The use of drugs to help people cope with a 24-hour society, perhaps under employer pressure, is another potential growth point that may need to be addressed. So is the possibility of 'cures' or vaccinations to treat addiction. Like other potential developments discussed in the course of this project, these possibilities raise both scientific and ethical issues related to choice and the protection of society and individuals. This would apply in particular to the application of developments in the area of genetics, about which debates are likely to continue.

We are sure that the issues encapsulated here will still be important in 20 years, for a number of reasons. One is that for thousands of years individuals have used some form of mind-altering chemicals, ranging from comparatively harmless substances, like coffee, to others with substantial scope for harm and abuse. Repeated use, addiction and other harms have, similarly, been with us for a long time, but we are only now understanding the neural basis of this vulnerability. While the use of some of today's psychoactive substances, such as tobacco, is stabilising or declining, the use of others is rising.

The number of older citizens in the UK and elsewhere in the developed world is increasing. This may lead to a demand for treatments to address cognitive impairment, allowing older people to function effectively for longer.

As with all Foresight documents, this Horizon Scan is designed to inform readers, help policy formation and planning, and promote debate. It is not a statement of policy from any part of UK Government and does not represent the Government's views on or vision of the future.

# Psychoactive substances in the UK in 2005

During the last twenty years, problem drug use has risen, but in the last four years use has stabilised. It is not possible to predict whether the future will follow the long-term pattern or the more recent trend.

The main issues addressed by the Foresight Brain Science, Addiction and Drugs project – what the psychoactive substances of the future will be, what their effects will be and how we can manage them – will still be important, regardless of whether their use remains at current levels, declines or increases.

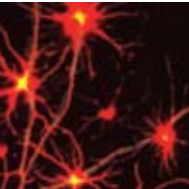
## **Alcohol**

The General Household Survey (GHS) 2002/2003 (Office for National Statistics, 2004) showed that of the population of England, 37% of men had drunk more than four units of alcohol at a single sitting at least once in the previous week, and 22% of women had drunk at least three units in the previous week; 27% of men drank more than the previously recommended sensible level of 21 units per week, the same as in 1992, and 17% of women drank more than 14 units a week, up from 12% in 1992. A quarter of 11–15-year-olds had drunk alcohol in the previous week. Alcohol accounted for 6% of household expenditure.

The longer-term data suggest that the percentage of men drinking heavily had not altered significantly between 1998 and 2002. There had been a small decline in heavy drinking among men aged 16–24. But there was a significant increase in the number of women drinking heavily, especially younger women. In 2002/2003, 28% of women between 16 and 24 had drunk more than six units in one session in the week before questioning. Only 1% of women aged 65 or over had done so.

Seven per cent of UK adults are dependent on alcohol, which, according to the Government's alcohol harm-reduction strategy (Cabinet Office, 2004), is associated with 22,000 premature deaths a year; 30,000 hospital admissions per year are associated with alcohol abuse; as is about 50% of violent crime – a total of 1.2 million incidents per year. Men and women receiving prison sentences are especially likely to use alcohol in large amounts. Alcohol-related harm is priced at £20 billion a year for the UK in terms of lost economic production, health-care, crime and other costs to family and society. Alcohol brings in about £8 billion per year in revenue to the UK Treasury.





## **Tobacco**

By contrast with alcohol, smoking is on the decline in the UK. According to the GHS, there are about 12 million adult cigarette smokers, and another 2.3 million (mainly) men who smoke cigars and pipes. There are 11 million ex-smokers. In 1974, 51% of men and 41% of women smoked, but by 2003 the figures were 28% and 24% respectively. Smoking is more prevalent among lower socio-economic groups and among the young, many of whom give up in later life. In 1974, 45 per cent of British adults smoked. This figure declined to 35% in 1982 but has remained stable for a decade since reaching 26–28% in 1992.

Smoking is associated with a fifth of deaths in the UK, over 106,000 a year according to the figures released by the Health Development Agency (The smoking epidemic in England, 2004), and with a third of all the cancers. Because of its greater prevalence among the lower socio-economic groups tobacco use is a contributor to health inequalities.

## **Cannabis**

The British Crime Survey (BCS) 2002/2003 gives an estimate of 3,357,000 adults aged 16–59 (approximately 11% of adults) who had used cannabis in the past year, and 2,068,000 (approximately 7%) who had used it in the last month. The figure for 'last month use' is considered a much closer proxy for regular users than 'last year use', which includes one-off and infrequent users as well. The value of the trade in cannabis has been estimated at about £5 billion, a figure with an exceptionally wide error margin, according to the Independent Drugs Monitoring Unit. Forty-four per cent of UK 16–29-year-olds have tried it, according to the BCS. It is associated with 76% of UK drug arrests.

In 2001/2002, 15% of men and 9% of women aged 16–59 said that they had used an illicit drug in the previous year, and 35% of men and 24% of women aged 16–24 said the same. In this age range, cannabis was much the most common illegal drug and had been used by 33% of men and 21% of women according to the BCS.

## **Ecstasy**

About 5% of 16–29-year-olds in the UK reported using ecstasy in the previous 12 months during 2000/2001. The figure (for England and Wales, as found by the BCS) is highest in 20–24-year-olds, at about 9% of men and 4% of women, and lower for the older and younger age groups.



## **Cocaine**

Cocaine use has grown in the UK in recent years as prices have fallen from about £70 to about £40 per gram. According to the BCS, in 2003, about 640,000 people reported that they had used cocaine at least once in the past year, three times the figure for 1997. In 2003, 113 cocaine-related deaths were recorded in the UK.

## **Heroin and other opiates**

Heroin prices have fallen steeply in the UK. Most heroin consumed in the UK comes from Afghanistan where there has been rapid political change and increased exports. There may now be over 150,000 regular users in the UK. There are several hundred deaths per year linked to heroin misuse, but the numbers have been declining (BCS).

## **LSD, magic mushrooms, solvents**

Use of these appears to be reducing or stabilising.

## **Cognition enhancers**

Dozens of drugs are in use or under development for neurodegenerative conditions, such as dementias, and other cognitive deficits, including attention deficit disorders. There are now ten times as many methylphenidate (Ritalin) prescriptions in the UK as there were ten years ago – 250,000, up from just over 20,000.

## **Young people**

Table 1 sets out what people aged 16–24 admit to. It shows that last year, use of cannabis, which is an indicator of one-off and infrequent use as well as regular use, is high but reducing slightly. Cannabis is by far the most commonly used controlled drug among young people.

**Table 1: British Crime Survey 1998–2003/2004 figures for the percentage of 16–24-year-olds reporting having used drugs in the last year**

Drug	Year					
	1998	2000	2001/2 <sup>1</sup>	2002/3	2003/4	
<b>Class A</b>						
Cocaine	3.1	5.2	4.9	4.7	4.9	* <sup>2</sup>
Crack	0.3	0.9	0.5	0.5	0.4	
Ecstasy	5.1	5.6	6.8	5.4	5.3	
Hallucinogens	5.3	3.4	2.0	2.0	2.9	*
Magic mushrooms	3.9	2.4	1.5	1.7	2.7	
LSD	3.2	2.5	1.2	0.8	0.8	*
Opiates	0.8	0.8	0.3	0.2	0.4	
Heroin	0.3	0.8	0.3	0.2	0.4	
Methadone	0.6	0.1	0.0	0.1	0.2	
<b>Class A/B<sup>3</sup></b>						
Amphetamines	9.9	6.2	5.0	3.7	4.0	*
<b>Class B/C<sup>4</sup></b>						
Tranquillisers	1.5	1.5	1.0	0.8	0.8	
<b>Class C</b>						
Cannabis	28.2	27.0	26.9	25.8	24.8	*
Anabolic steroids	0.5	0.1	0.2	0.1	0.3	
<b>Not Classified<sup>5</sup></b>						
Amyl Nitrite	5.1	3.9	3.8	4.3	4.4	
Glues	1.3	1.0	0.6	0.5	0.5	*
<b>Total</b>						
Class A	8.6	9.7	8.8	8.2	8.3	
Any drug	31.8	29.9	29.6	28.1	27.8	*
Frequent use of any drug <sup>6</sup>	-	-	-	11.3	12.0	

1. From 2001, the reporting year for BCS data switched from calendar to financial years.
2. <sup>1</sup>\* indicates statistically significant difference between proportion of 16-24 year olds that reported using in 1998 and proportion that reported using in 2003/04 (at the 5% level).
3. Amphetamines can be classified as either Class A (prepared for injection) or Class B (powdered). For the purposes of calculating Class A drug use, the BCS assumes all reported amphetamine use to be of the Class B variety.
4. Tranquillisers can either be classified as Class B (e.g. barbiturates) or Class C (e.g. benzodiazepines). Consequently, Class B and Class C drugs cannot be aggregated reliably because the survey does not identify which specific tranquilliser respondents used.
5. Indicates that it is an offence to supply these substances if it is likely that the product is intended for abuse.
6. Indicates users who took a drug (or several drugs) more than once per month in the last year.

## **Coffee**

Caffeine is the world's most-used psychoactive substance. The 51 exporting nations of the International Coffee Organisation produced just over 100 million 60kg bags of coffee in 2003 i.e. 6 million tonnes. Coffee is the world's most valuable export after oil. It is not associated with major harm.

## **Trade routes**

Tobacco and alcohol are major world industries with sophisticated manufacturing and distribution. Taxes on their products provide an important contribution to government finance in many countries.

Illegal plant-derived drugs are traded both within and between nations, via networks which are also able to convey other high-value items and are thought to be very profitable. These networks are highly flexible in terms of products, sources and markets. The people involved are often enthusiastic early adopters of new technology, especially for communications.

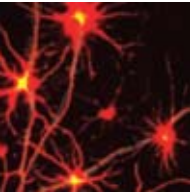
## **Medicines for mental illness**

There were about 750,000 people in the UK with dementia in 2004 and the figure is set to rise to 870,000 by 2010 and 1.8 million by 2050, according to the Alzheimer's Society. Of these cases, 55% are sufferers of Alzheimer's disease. A range of treatments is becoming available for the symptoms of this and similar diseases but no cures have emerged. It would be no surprise if usage of drugs and therapies for dementia grew considerably in the coming 20 years.

Five million people in Europe and 18 million in the world were suffering from dementia in 2004. By 2025 there could be 34 million sufferers in total, with 71% in the developing world. In addition, drugs to treat dementia may be used as cognition enhancers by people with cognitive function in the normal range. This has already happened with donepezil (Aricept), a drug for Alzheimer's sufferers.

## **Behavioural addictions**

The most widespread behavioural addiction is gambling. The charity Gamcare estimates that there are 300,000 problem gamblers in the UK. Gambling has traditionally been largely a male pursuit but this gender gap is closing. Problem gamblers often also drink heavily.



# Future implications for society

## Social trends

The public attitude to drug taking is changing as knowledge of drug effects and side-effects becomes more widespread. The addict is increasingly seen as someone to be treated rather than punished. An addict's problems may be considered more sympathetically as it is realised that addictive drugs directly affect the brain regions that govern volition and control. In parallel with this trend, there may be more awareness of the dangers of drug taking. These shifts in attitude may require the consideration of novel, evidence-based regulatory responses that integrate information from all areas of relevant science, including economics and other social sciences as well as brain science.

## Ethics

Ethical analysis is an area of growing relevance in relation to both drug addiction and brain science. Some issues, like vaccination, have already attracted attention. New laws, for example, those allowing the testing of arrestees for drugs in certain situations raise new ethical questions about the appropriate level of state involvement in personal choice. Improvements in detection systems will lead to new ethical challenges such as, whether or not to test schoolchildren. Both sides of the argument will need to be considered in this debate.

By 2025, vaccinations for a growing number of common drugs of addiction, such as cocaine, heroin, nicotine, amphetamines and cannabis, will almost certainly be available to prevent initiation of, or to treat, drug misuse. Vaccination offered to drug users as a treatment of their addiction raises few ethical dilemmas. But there are more difficult scenarios. One is that some parents may wish to vaccinate their children as a preventative measure. Another is offering vaccination treatment as an alternative to prison.

This is one example of the continuing issue of how appropriately to balance the entitlement of a drug user freely to make personal choices with the need to address any competing public interest. If insurance companies were to encourage, or even require, vaccination against high-health-risk drugs such as tobacco, such ethical issues would be likely to come to the fore.

The technology for wide availability of screening of the genome using gene chips is likely on the timescale we are considering. The application of this technology could, for example, help to assess an individual's sensitivity to drugs and the likelihood of dangerous drug interactions, and also their liability to drug addiction. Parents might wish to explore the use of vaccination and other prevention measures following the application of such technology in an attempt to reduce the addiction risk in their children.

The ethical debate about whether or not to use drugs to improve performance in normal schoolchildren and students will probably be resolved over the next 20 years. Similarly, there will probably be continued debate about the ethics of using cognition enhancers in the workplace.

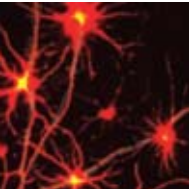
Another ethical issue concerns the potential development of drugs that have pleasurable or enhancing effects but few adverse effects and are neither categorised as medicines nor restricted as 'controlled drugs'. How will society view the appropriate control of drugs that are relatively safe and are not required as treatment? What level of risk in such cases would be appropriate? Are the public entitled to some system of checks or controls as may be applied to vitamins in the future or would some other level be needed?

## **Future drug use**

Drugs are used for a wide range of purposes, including to improve sleep, increase alertness, have fun, and to elevate mood. The intention behind the use of a substance can be as significant as the nature of the drug itself. Thus, therapeutic psychoactive substances of the future may also be pleasurable to use. Many of the current illicit drugs have – or have had – therapeutic uses. Until the 1960s, amphetamine was used in therapy, but also quite legitimately at that time by prime ministers and politicians, transport workers and medical staff to remain alert over long hours. Psychoactive substances may be used to optimise performance, relieve distress, treat mental illness, help people relax, or aid sociability.

Many of the drugs of tomorrow will be the drugs of today, but there will continue to be change due to fashion, innovation and availability.

Even without the discovery of new psychoactive substances, drug misuse might rise, fall or stabilise in future. However, factors which suggest that we have not reached a ceiling for recreational drug use include the potential for a narrowing of the gender and race divide in the prevalence of illicit drug use and alcohol consumption (females catching up with males, black and ethnic minorities catching up with the white British); earlier age of commencement of drug use; and a prolongation of 'youth' with an increasing proportion of young people spending longer in education and delaying starting work or families of their own until later in life.



By 2025, the generation which saw the first expansion of illicit drug use in the UK – those who were in their 20s in the mid-1960s – will be in their 80s. With the proliferation of illicit drug use in subsequent decades, most families will have had some experience of illicit drugs through several generations. This means that psychoactive drug use may spread more across the life course and may become more common than is currently evident in middle-aged or even older age groups.

Many of the current plant-based products such as heroin, cocaine and cannabis are likely to remain available. Prices of such illicit drugs have fallen and are likely to continue to do so. They are currently produced in poor and marginal populations and in countries where their production is linked with instability and conflict. This situation is likely to continue.

There are occasions when 'newer' drugs emerge to prominence, such as LSD<sup>1</sup> in the 1960s and MDMA<sup>2</sup> (known as ecstasy) in the 1990s. As with these examples, increased popular use of a drug can happen long after it is initially synthesized. LSD was first synthesized in 1943 and MDMA in 1912. While a number of newer drugs may become commonly used, they will probably not displace existing ones completely. There may be an expansion of polydrug use, with people selecting from a wide range of substances and using them together or sequentially. The potential for harm from polydrug use could be a particular challenge.

## **New sources**

Development of new medicines is likely to be a growth area in the next 20 years. New drugs will be developed and produced by pharmaceutical companies, research institutions, and laboratories, as well as by illicit sources.

Knowledge of how to produce illicit drugs and the facilities to produce them are likely to spread between countries. Most illicit drugs are relatively easy to manufacture and require limited technical knowledge, specialist equipment or additional specialist raw materials. During the last 30 years, for example, heroin production shifted from the Mediterranean to south-east Asia, then to south-west Asia, and then to the Andean region of Latin America. In the last ten years, illicit drug producers in south-east Asia have switched to the production of amphetamine-type drugs. There is the potential for illicit drug manufacture to occur in many countries. By 2025, it may become simpler to make drugs at home, although doing so might raise severe issues of quality control.

1. *LSD: lysergic acid diethylamide*  
2. *MDMA: 3-4-methylenedioxymethamphetamine*

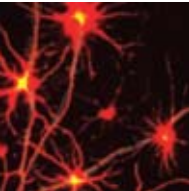
## **Treatment and performance drugs**

Prescription drug use may grow because of demographic change. The elderly population is growing and will increase the demand for drugs to treat the mental effects of ageing. Cognitive impairment might replace physical impairment as a main reason for providing health and social care for the elderly. Long-term healthcare for a cognitively impaired population will become a major cost to society.

Impaired cognition and alertness affect many otherwise healthy people as a result of ageing, shift work and sleep disorders. Many people are likely to use over-the-counter remedies with psychoactive effects such as herbal stimulants, tonics and caffeine, to improve performance at work or in school.

Cognition-enhancing drugs will probably be developed for therapeutic purposes, but use of these drugs may well spread to the enhancement of the healthy, and their effects could influence many aspects of mental functioning, including performance, mood, cognition, pleasure and sexual performance. Many agents, including drugs such as methylphenidate, and foodstuffs (Box 1) that affect the brain (so-called nutraceuticals), are available though the Internet and this form of distribution is set to grow.





## **Box 1: Diet, drugs and the brain**

Neurotransmitter substances are generally fairly simple molecules ranging in structure from monoamines to amino acids and polypeptide structures. They are all made within the brain, often from precursors that may include amino acids that we derive from our diet. There is now considerable evidence that brain levels of central serotonin, acetylcholine and dopamine can be affected by dietary intake respectively of tryptophan (in cheese and yoghurt), choline (in milk, peanuts and liver) and tyrosine (in spinach, tuna and turkey). This has been found by experiments in humans as well as experimental animals, showing that otherwise balanced diets lacking one of these essential amino acids produce significant though transient reductions in the respective neurotransmitters. The cognitive and behavioural effects of these manipulations are often subtle, although they can be theoretically important. For example, the fact that tryptophan depletion can cause relapse in remitted cases of depression is supportive evidence of a serotonergic basis for some forms of depression. On the other hand, choline supplementation to remediate the effects of cholinergic loss in patients with Alzheimer's disease was not shown to be therapeutically effective. A practical case of how dietary regulation can affect central functioning comes from the use of phenylalanine-free diets which help to prevent the mental retardation associated with the single-gene metabolic disorder phenylketonuria.

Vitamins such as thiamine (B1) are known to be important for the maintenance of neural function. Korsakoff's disease, which arises from the nutritional deficiency occurring as a consequence of alcoholism, is a severe syndrome of amnesia, cognitive and motor deficit arising from damage to structures such as the thalamus and mammillary bodies that contribute to the Papez circuit implicated in memory. There have been claims that vitamin supplements, such as Vitamin C (ascorbic acid), have mild cognition-enhancing properties, and it is likely that there will be considerable research in the future aimed at understanding the relationship between our diet and brain function.

There are already psychoactive substances available that could be used to treat addiction. There may be many more drugs available for such purposes by 2025. This suggests the development of a 'cosmetic' psychopharmacology that goes beyond therapeutic uses of such drugs.

## **Non-pharmacological techniques**

By 2025 there are likely to be advances in the non-pharmacological manipulation of brain activity using transcranial magnetic stimulation (TMS) (based on the use of pulsed magnetic fields) or neural prosthetics (the intra cranial implantation of computer-chip models of brain function or implanted brain stimulators) to replace damaged, or modify dysfunctional, brain tissue. TMS is already able to influence

many brain functions including movement, visual perception, memory, reaction time, speech and mood. The effects currently produced are genuine but temporary, lasting only a short time after the stimulation has stopped. Brain stimulation is showing promise in neurology and the treatment of resistant depression.

## **Behavioural addiction**

The term 'behavioural addiction' includes excessive behaviours in areas such as gambling, eating and sex. These share many similarities with addiction to drugs. For example, they are initially pleasurable but later, when they take over control of the person's life, are disliked and resisted, usually unsuccessfully. The experiences of pleasure that winning at gambling, addiction to sexual intercourse and compulsive eating can give, are similar in direction and can be of the same magnitude as those caused by drugs of addiction. Both types of behaviour can change people's lives to the detriment of family and work. Preliminary evidence suggests that similar brain regions and processes are involved.

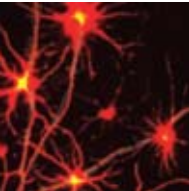
The increasing sophistication of communication technology such as the Internet and mobile phones may lead to an increase in gambling and to new behavioural addictions, for example, to Internet chat rooms. Improvements in mathematical techniques and video presentation will increase the frequency of 'near win' experiences in gambling and make it more addictive. Easy availability, rapidly achieved and intense emotional reward, and the opportunity for continuous or quickly resumed play or consumption all enhance addiction potential. Innovations could include gaming machines with unlimited stakes, prize machines in casinos and jackpot machines elsewhere, and further use of the Internet for gambling, games and chat rooms.

By 2025, neuroscience research may have clarified the brain circuits that are involved in behavioural addictions and excessive appetites. Many of the neurotransmitters systems involved may have been identified by then too. And new drug treatments could be under investigation, though they will probably not have received a marketing authorisation on this timescale.

## **Effects of drug use**

It is difficult to predict whether the prevalence of problematic psychoactive substance use will rise, fall or stabilise over the next 20 years. But the effects of drug use are likely to include a continuation of drug-related deaths, blood-borne infections, disruption of family life and economic and social costs.

An increase or decrease in problem drug use might have considerable impacts on social attitudes, drug policy and foreign policy, though it is not easy to forecast in which direction.



## **Changing views on drug use**

Societies and subgroups within them are more tolerant of some psychoactive substances than others. The reasons for this are a mixture of history, evidence, fashion, morals, identity and status. How different psychoactive drugs are viewed can change rapidly. Some substances will become more accepted and others fall into disfavour. It is likely in the future that acceptance will be based on evidence of safety and harm.

A process of change, extending over 40 years and not yet ended, has fundamentally altered the cultural and political position of cigarettes and other smoked forms of tobacco in the UK. Cigarette smoking is now particularly associated with poverty and marginality. In most developed countries and some developing ones, cigarette smoking has been – or is in the process of being – banned from public places.

In UK and the rest of western Europe, the past 20 years have seen a shift in public attitudes with regard to cannabis. At times, there has been a greater use of drug references in films, music and advertising. Instead of being simply a representation of evil, drugs have been used at times as an image for selling to young people. This may have contributed to an increase in drug use among young people. It cannot be ruled out that there would be a further shift in attitudes in the future.

Psychoactive drugs are likely to remain familiar and society could see a wide and at times vociferous debate on their use and management. The discussions are likely to reflect tensions between consumerism and individualism on the one hand, and a greater concern and restrictive approach as the harms drugs cause to individuals and society become more familiar.

A more sophisticated understanding of the mechanisms and components of addiction as we understand it today may expand the concept. This could involve new insights into the experience of pleasure and excessive and compulsive behaviour.

The boundaries between using drugs to treat disease, for mental enhancement, and for pleasure could become increasingly unclear. For example, the treatment of an ageing person with a cognition enhancer could effectively treat a disease, enhance their mental condition and improve the pleasure they get from life.

This will raise questions about what enhancement and pleasure are and where the boundary lies between different targets for modification. What is a disease, what is normal deterioration and what is enhancement of normal capacity are likely to become topics of debate. In addition, the historical view of addiction and dependency as moral weakness may well be abandoned with enhanced understanding. Wider knowledge about the mechanisms affecting individual control, choice and behaviour may lead to a new sense of determinism, which might alter

our sense of responsibility to ourselves and the community. On the other hand, it could lead to a destigmatisation of addiction and compulsions.

The development of more sophisticated understanding and targeting in the treatment of mental illness may lead to reconsideration of the current classification of some disorders. The ability to 'treat' more aspects of psychological discomfort – such as shyness and other 'social' impairments – is likely to influence discussion about the role and limits of psychiatry.

## **Drug regulation**

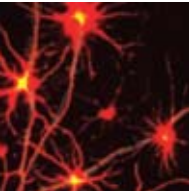
Social awareness of the wide range of substances and behaviours which are mind-affecting, an increasing knowledge of the effects of psychoactive substances, and the emergence of substances which have lower health risks will raise questions about the adequacy of the range of approaches taken to regulating alcohol, tobacco and illicit drugs. Newer drugs and other ways of affecting the mind may not fit easily into the current legislative apparatus. How would a government regulate a drug that is not used as a medicine, is used solely for pleasure or enhancement, and has few apparent adverse effects nor any apparent addiction potential (and so may not be liable to become a 'controlled drug')? Similar issues have been raised concerning appropriate regulation of vitamins.

Non-synthetic drugs such as herbal products will probably be considered unsafe unless they have been evaluated with the same rigour as synthetic pharmaceuticals and may be less readily available than today.

Many government departments are involved in one way or another in doing something about the production and consumption of psychoactive substances, which may encourage, modify or discourage production and consumption. They also attempt to limit harms to the individual and society, for example, the departments in the fields of revenue, agriculture, international relations, education, health, policing, and criminal justice.

Drug regulation methods typically target:

- **the product.** Societies can regulate or ban products. Consumption can be discouraged through taxation. Regulatory systems may control quality, safety, efficacy, strength, size, labelling, advertising and claims made for a product.
- **the provider or seller.** Societies can limit who can provide or sell the product, authorise its provision or sale, and impose responsibilities on those providing or selling it.
- **conditions of sale and use.** There may be restrictions on who may buy the product, such as minimum-age restrictions, or on where and when it may be sold and consumed.



- **buyer or consumer.** Government may prohibit or set limits on purchases by individual customers, or seek to influence the behaviour of users by providing health education, laws on behaviour while or after drinking, and by providing treatment for people who have problems with psychoactive substances.

There are likely to be arguments for greater controls over the possession and use of some substances that are relatively weakly controlled, such as tobacco. The current perceptual landscape of 'good' and 'bad' drugs is likely to change, as are the ways in which they are regulated.

Regulatory approaches today differ for tobacco, alcohol and illicit drugs. This is most apparent in international regulations. The tightest international controls are applied to 'controlled drugs' such as the opiates, cocaine and cannabis. Alcohol is a prominent psychoactive substance that is not controlled internationally. International agreements treat it as a commodity and tend towards a liberalisation of its trade. Pharmaceutical drugs are regulated internationally by patents that restrict their production. International controls on tobacco are weak but emergent, such as the Framework Convention on Tobacco Control.

Within countries there are usually different regulatory frameworks to manage different classes of psychoactive substances. In the UK, the Misuse of Drugs Act classifies psychoactive drugs according to assessment of their harm for the purpose of controlling their possession, sale and use. The manufacture and distribution of pharmaceutical drugs used in the treatment of illness is controlled by the Medicines Control Agency. Tobacco is mainly controlled by taxation, regulations as to sale (e.g. not to minors), restrictions on advertising and where it may be consumed. Alcohol is controlled through taxation, and a variety of regulations that affect advertising, when and where it may be sold, product labelling, and consumer behaviour, for example public drunkenness and drink-driving.

These mechanisms may well be perceived as increasingly inflexible and slow to adapt to changing circumstances. New or modified regulatory mechanisms may be required to control the development and production of products that are currently unregulated or for which there are inadequate regulatory mechanisms. Examples include performance-enhancing drugs, which are not currently regulated as medicines.

Today's separate ways of controlling alcohol, tobacco, currently illicit drugs, over-the-counter medicines, nutritional supplements, herbal medicines, new pharmaceuticals, such as performance-enhancing drugs used for non-medical purposes and non pharmaceutical products for affecting mood may need to develop in order fully to address this range and complexity. Updated or new regulatory mechanisms are likely to be required for the rational assessment and control of existing and new psychoactive substances.

Finding effective solutions to the harms of psychoactive substance use is likely to remain a key issue and will continue to evolve, reflecting new evidence and society's changing concerns.

In the case of alcohol, it is likely there will continue to be differences of view as to the appropriate balance between policy approaches aimed at altering the availability of alcohol and those directly addressing the harms related to alcohol consumption. In the next five to ten years these are unlikely to be fully resolved.

Alcohol and tobacco have escaped the level of scrutiny that other public health issues have faced in a number of countries. However, there may be international conventions on tobacco or alcohol that develop in time.

There may be increasing tensions between global and national control. Improvements in communication and transport have made contact between different cultures and countries routine. In the torrent of travellers and trade goods, governments have found it increasingly difficult to control what crosses their national or regional borders. The Internet is also expanding the availability of psychoactive medications, removing physician oversight and increasing exposure to risks from lack of other effective controls.

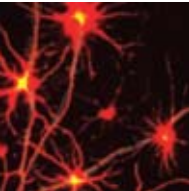
Drug policy must take account of the international context, such as supply routes; the national context by considering harm reduction to the population; and the local situation in order to lead to an effective local solution.

Consumer sovereignty is a further political argument against differentiated controls that affect consumers in different places differently. Policies will need to be acceptable in increasingly diverse societies.

## **Future treatments**

The relationship between addiction doctors and their patients is likely to change in the next 20 years. Like healthcare consumers generally, drug users may become more discerning and ask for more evidence for the advice they receive. And the problems drug users present are set to become more complex. First, more polydrug use means it is likely there will be greater numbers who require the focus of treatment to be on the harmful use of a number of substances rather than dependence on a single substance. Some such individuals may require more complex and individualised combinations of treatments. Second, if the numbers of drug users from more affluent, educated and middle-class backgrounds were to increase, they could become a more demanding client group that expected provision to be tailored to their needs.





The Internet is a major source of information about drugs and their effects. A growing number of web sites advertise affordable online therapy by 'trained experts' for addictive disorders. One advantage claimed for this approach is that the treatment is convenient and private. In the future, such programmes could provide many of the benefits of traditional methods, including group sessions led by addiction counsellors, peer support and psycho-educational tools such as videos. 'E-counselling' enables therapy or counselling from a distance.

The provision of treatment for and research into behavioural addiction lags behind that for substance addictions, with some exceptions in the field of problem gambling. Some treatment is based on the 12-step philosophy as used in Alcoholics Anonymous and Narcotics Anonymous. Other services use cognitive-based learning programmes, or access to motivational enhancement therapies (MET (Box 2)). There are clear problems in the evaluation of many of these programmes.

## **Box 2: Motivational enhancement therapy (MET)**

<http://www.motivationalinterview.org/clinical/METDrugAbuse.pdf>

Apathy and depression are common states associated with drug addiction, and are especially associated with withdrawal. Motivation must also be exerted to prevent relapse, perhaps by focusing on future outcomes to overcome the preference for short-term gain at the expense of long-term profit, which is characteristic of addiction. In common parlance, the addict has to exert will-power to overcome the urges produced by drug cravings. Thus, motivational therapy can potentially play an important role in the treatment of addiction, and this is at the basis of MET.

As described by W. R. Miller, it is based on principles of motivational psychology and is rooted in a clinical approach known as motivational interviewing, being particularly directed towards alcoholism. It is offered to drug users who have committed to engagement in a treatment programme. The MET manual describes several elements of the therapy arranged around the acronym FRAME (Miller and Sanchez 1994):

- FEEDBACK of personal risk or impairment
- emphasis on personal RESPONSIBILITY for change
- clear ADVICE to change
- a MENU of alternative change options
- therapist EMPATHY

This results in the facilitation of client self-efficacy or optimism.

The treatment is relatively short-term, and clinical trials are now ongoing, so we are awaiting evidence of outcome effectiveness.



# Our emerging knowledge

## **Advances in neuroscience**

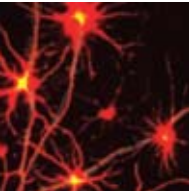
Brain science, drugs and addiction involve several rapidly-moving areas of neuroscience and, indeed, of science in general. There are new conceptual advances in experimental psychology, technological advances in neuroimaging and advances in our understanding at the molecular and genetic levels.

Within the next few years, we expect to have a good understanding of the main neural components of motivated behaviour, and how these are affected by drugs and other reinforcers such as money. There have been rapid advances in understanding the nature of the overlap between the brain systems implicated in drug abuse and compulsive gambling and those systems controlling behaviour motivated by natural rewards such as food. The current focus is to understand how the systems mediating drug addiction differ from those implicated in normal motivation.

The other anticipated areas of major advance will be in finding the molecular correlates of these processes, and in analysing the neuropsychological processes involved in relapse to drug taking. This science could help to inform a more developed rational basis for understanding relapse in the next five years.

Our understanding of the neural basis of cognition has also made dramatic advances and is only a little way behind our understanding of the motivational systems. The next goal is to find how cognition-enhancing drugs and those that are abused affect the brain mechanisms controlling cognition.

In parallel with this are startling new juxtapositions of neuroscience with social psychology and economics that may enable us to understand the neurological basis for sophisticated decision-making, and how this may be affected adversely by drugs. This knowledge will affect our perception of the addict and our attitudes towards drug abuse and behavioural addiction. Another major scientific advance will be to understand the basis of individual differences in responses to drugs. This will capitalise on our increasing knowledge of the genome and our ability to apply this learning. In 20 years genotyping could be widely available at birth for children in the developed world.



## **Scientific approaches to addiction**

One goal of neuroscience in relation to addiction is to determine the brain circuits that mediate the key elements of addiction. These include pleasure and reward, craving and the urge to use drugs, and withdrawal. Another goal is to understand at the molecular level the processes that mediate the actions of drugs of addiction, and relate these molecular processes to their associated behavioural processes. Molecular targets here are the neurotransmitters and their receptors that drugs of addiction act on, the second-messenger intracellular mediators of these neurotransmitters and the genes that are subsequently turned on or off by them.

Research to date has shown a progressive increase in the intensity of individuals' drug-directed behaviour, as addiction grows stronger, alongside a reduction of other previously pleasurable activities, evidence of craving and withdrawal, and the provocation of relapse by stress and other drug use. There is good evidence for the involvement of several neurotransmitters in addiction, including dopamine, glutamate and gamma-aminobutyric acid (GABA). One exciting recent insight is provided by the finding that the density of brain dopamine D2 receptors predicts whether individuals find stimulants pleasurable or not.

Key neural processes in addiction include learning and memory, action and motivation. By 2025, the brain circuits of these processes should be well understood for most of the different behavioural elements of addiction. The molecular mechanisms underpinning these will probably be worked out for a number of synapses in these neuronal circuits. New targets for drug interventions at receptors and second-messenger or gene modulators may have been discovered and some may have been licensed. Experimental work with these may have been carried out in human volunteers including addicts. This research may illuminate behavioural as well as substance addictions.

## **Drug innovation**

It is likely that individual differences in drug responses may depend in part on genomic effects. Elucidating them would be helped in turn by substantial levels of genotyping, by genetic profiling, and the discovery and description of gene variants affecting drug actions. This could potentially allow information technology and education to be used, for example, as the basis for web-based enhanced personal control of use of medication.

In terms of controlled psychoactive drugs, we assume that fashions will change and that new drugs will emerge, possibly serendipitously, in the stimulant or opiate class. Indeed, brain receptors have been identified which may act as binding sites for future drugs.

Commercial and scientific developments in pharmaceutical companies will lead to the discovery of potent drugs that affect the brain's reward systems. These may be matched by products from increasingly sophisticated illegal enterprises beyond UK jurisdiction.

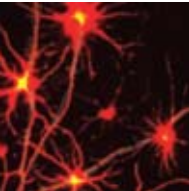
Some drugs emerging from cognitive development programmes might be effective alternatives to nicotine agonists. They may also be addictive but otherwise might offer an effective recreational substitute for smoking tobacco. This would force us to appraise the way we manage nicotine addiction that might not necessarily lead to lung and heart problems.

A further class of drugs that will probably become abused will be those that do not affect the brain's reward systems directly, nor lead to cognitive enhancement, but nevertheless have 'mind-altering' psychological effects. Examples of these are hallucinogens, sedatives, dissociative agents like ketamine, solvents and other commonly available chemicals. Changes in the use of such substances are difficult to predict.

The biosciences industry is producing drugs to treat addiction. However, their impact and risks are hard to predict. For example, a cannabinoid receptor antagonist, rimonabant, may have several uses – as an antidote to the intoxicant effects of cannabis, a treatment for heroin relapse and as a cognition enhancer in its own right. But such drugs may be put to unexpected uses. Using drugs to reduce the side-effects of drugs of abuse may be a way to enhance the 'high' which they produce. Again, a more sophisticated approach than today's can be expected in coming years, partly prompted by advances in the treatment of addiction and its side-effects. Drug users may self-treat the sedative consequences of their drug taking and also attempt to avoid the effects of dependence and withdrawal.

Another upcoming issue may be the possible side-effects of drugs used to treat dependence, such as methadone. More effective compounds may become available. We can expect vaccination against selected drugs to become a possible strategy for treatment, although probably only for highly dependent individuals as a last resort. Drugs that can reduce craving and risk of relapse, for example, by selectively producing amnesia for drug-associated stimuli, may become available for clinical trials.

Many 'new' drugs may emerge from the discovery or rediscovery of unknown or little-appreciated actions of older drugs. This often happens when an enthusiast experimenting with drugs publicises his or her experiences. The Internet has massively increased the capacity for this kind of exposure. Sometimes a new drug emerges when a new method of administration is discovered that changes how that drug impacts on the brain. Novel drugs may emerge on the same basic design as compounds such as amphetamine or morphine but with 'purer' neurochemical



actions which make them more potent and with fewer side-effects, but also with the possibility of new harms.

Some new drugs will probably emerge from research on known brain structures and on 'orphan' receptors with unknown functions that help to define new structural requirements for compounds. Thus, the orexin and leptin systems will undoubtedly give rise to new compounds regulating arousal, appetite and weight change. Other new drugs will result from our increasing understanding of the variation in composition that can occur in common receptors such as glutamate/N-methyl-D-aspartate (NMDA) and GABA. The varying composition of receptors in terms of protein subunits means that they have subtly different properties and are often involved in different effects according to their differing distribution in the brain. So drugs could be capable of targeting specific brain regions, even when taken orally. It is likely that there may also be attempts to improve substance delivery to the brain through advances in neurosurgical procedures. This could result in new drug treatments becoming available, including some that use compounds which are poor at penetrating the brain.

New drugs will emerge from our greater understanding of the sequences of chemical reactions, or molecular cascades, involved, for example, in the consolidation and subsequent manipulation or processing of memories. Studies have shown that it is possible selectively to produce amnesia for a particular memory that is retrieved in specific contexts. Such treatments might become valuable for the treatment of conditions such as post-traumatic stress disorder as well as drug craving. It may also be feasible to boost specific memory traces, leading to a new generation of cognition-enhancing drugs which make it feasible to recall an original drug experience and boost it, rather than experience tolerance. The role of sleep in processing memory traces is also becoming clearer. These include beneficial effects that may become amenable to pharmacological manipulation using novel hypnotic agents.

There will be increasing awareness of the cognitive and mood-altering effects of nutrients. Whether the drugs and food industries can take advantage of this remains unclear.

## **Drug combinations**

Combining compounds can produce a range of effects and side-effects. This might result in synergy, so that the effects of two drugs acting alone are much greater than the effect of a combination of the two doses. This can sometimes happen through interactions with peripheral systems rather than with the brain. One known dangerous product of drug combination is cocaethylene, which is a pharmacologically active derivative of cocaine formed during the co-administration of cocaine and alcohol and is highly toxic.

But other combinations could result in reduced side-effects, such as drugs designed to reduce hangovers from alcohol. Some polydrug abuse arises from drug combinations designed to exert different effects at different times. It is likely that different combinations will be used in years to come, and that they will lead to specific harms.

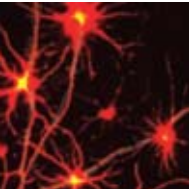
In the future, combinations may become much more sophisticated. Abusers might be able to take drugs that prevent the subsequent molecular adaptations that lead to a strengthening of the drug-taking habit through sensitisation or analogous mechanisms. This would allow drug taking while attempting to reduce the risks of the development of dependence, or of escalation through binge intake. The burgeoning availability of GABA-ergic agents being tried in the treatment of cocaine dependence might allow the user to adjust their consumption of cocaine by the use of drugs normally used for medical purposes.

## **Vulnerability and mental health**

Psychoactive substance use can cause harms to the individual or others. Central to thinking about harms has been the concept of addiction or dependence. However, people who are not dependent may still risk harms or cause harm or nuisance to others. Examples include binge drinking by people who usually drink modestly; drinking and driving; or the injection of a drug with an unsterile needle by someone who injects occasionally, leading to HIV infection.

Some behaviours can have psychoactive effects similar to those caused by taking psychoactive substances. Psychoactive effects can also be caused by interventions such as TMS or neural prostheses, which stimulate the brain through electronic probes. The development and refinement of such psychoactive products is yet to come but will probably happen within the time period of this report.

Future work on vulnerability to drugs and their harmful effects will involve assessing vulnerability both to physical damage and possible mental illness (Box 3). There are increasing signs of developmental and gender-based differences in these vulnerabilities. Recent studies have made it clear that the developing brain responds to drugs differently from the adult brain. This difference could underlie the unexplained efficacy of methylphenidate in attention deficit hyperactivity disorder (ADHD), and also the unexpectedly poor outcomes of psychological and drug treatment for childhood and adolescent depression. It could also indicate that children and young people are at particular risk from taking drugs. Considerable interest in this area can be predicted.



### **Box 3: Psychological testing for vulnerability**

Standardised psychological testing, probably using computerised tests based on sophisticated paradigms emerging from cognitive and experimental psychology, is anticipated to be a growth area in the near future. Such testing may be useful to predict such disorders as Alzheimer's disease and schizophrenia. Such prediction may enable treatments to be sought to prevent the person at risk from developing the full-blown syndrome; and may enable a disorder to be treated in its earlier stages. It is also possible that psychological testing, in combination with other measures, for example, based on genotyping, may be useful in assessing susceptibility to drugs of abuse.

Testing the general population would not seem feasible and would raise ethical problems. However, it is increasingly likely that such measures will be considered for large-scale prospective epidemiological studies of child development. There will also clearly be a need for improved psychological tests for the adequate evaluation of novel cognition-enhancing drugs.

### **Attitudes to innovation**

The possible availability of new drugs and their use, for example to alter cognition and mood, raises several questions. Some drugs used for cognitive enhancement may not be taken to produce mood changes and may not lead to physical dependence. Drugs such as modafinil (Box 4) and perhaps the new AMPA<sup>1</sup>-kines or GABA-ergic agents affecting cognition may be taken by users to combat fatigue and improve performance. However, the long-term consequences of prolonged use are not yet known. A new generation of highly specific drugs such as CREB<sup>2</sup> activators may arise from our understanding of the intracellular molecular cascades set in train by the initial binding of a neurotransmitter to its receptor.

1. AMPA: *alpha-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid*  
2. CREB: *cyclic adenosine monophosphate response element binding*

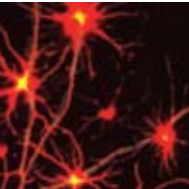
## **Box 4: Modafinil**

Modafinil is a wakefulness-promoting agent. Its precise mode of action is unknown but it probably affects the cerebral cortex indirectly, possibly via ascending histaminergic or GABA-ergic systems. It appears that modafinil exerts significant psychological effects in normal humans. These include enhanced vigilance, improved attention and working memory, and a capacity to suppress impulsive behaviour. This is demonstrated by its action to improve the ability to cancel a programmed or anticipated motor response or even improve performance on a planning task. A recent study showed small but significant improvements in a sample of intelligent healthy volunteers in tests of working memory that required the subjects to remember short strings of digits, the ability to recognise abstract visual images, and a test of planning involving the ability to look ahead. On the other hand no benefits were observed in tests of learning and long-term memory. These effects have encouraged the testing of modafinil in successful proof-of-principle studies of both juvenile and adult ADHD, as well as in studies of healthy shift workers, whose performance is often impaired as a consequence of altered sleep-waking cycles.

An important question to address is what proportion of modafinil's effects on cognition is attributable to its actions to elevate arousal. It is difficult to see how such an action can be responsible for its anti-impulsivity effects. The cognition-enhancing effects of modafinil are of possible clinical utility because the drug does not appear to have any potent dependence-inducing actions. It is not self-administered to any great extent by experimental animals, and potential human abusers are unable to inject it because of its insolubility. Coupled with what is only a slow capacity to penetrate to the brain, this makes it unlikely to have significant abuse potential. These characteristics have encouraged its use as a 'substitute' treatment for cocaine dependence, and a recent clinical trial conducted by the National Institute on Drug Abuse (NIDA) has reported encouraging preliminary results. Modafinil has also been used experimentally in subjects with chronic schizophrenia to improve cognitive functions.

What will be the attitude of society and the regulatory authorities to these drugs, if they do not cause antisocial behaviour, lead to crime or adversely affect health? The obvious comparison point will be with performance-enhancing drugs in sport, although these can adversely affect health. Despite the likely improvements in drug testing technology, it may prove increasingly difficult to detect and punish the use of such drugs. On the other hand, the development of drug-testing technology could make this testing faster, easier and quicker. This may have repercussions for their use in settings such as sport and student examinations. The attitude to the use of such drugs is currently much debated in terms of their desirability, benefits and level of risk.





It will be necessary to investigate the effects of these new drugs, including the consequences of long-term use, and compare their effects to the claims made for them, in order to enable individuals to make informed choices about the relative benefits and risks and to inform decisions about the drugs' management and control. This would require several developments including more sophisticated and objective means of detecting beneficial and adverse cognitive effects. Such analysis may lead to the realisation that drug-induced improvement is probably highly context-dependent and may have costs and harms in other contexts.

## **Imaging**

Imaging is the science and technology of allowing the structure and function of the living human brain to be investigated from outside, using sophisticated and currently expensive scanners. There are two main types of neuroimaging where advances in technology development are expected to have made a significant impact in addiction – position emission tomography (PET) and magnetic resonance imaging (MRI).

PET can be used to label receptors and other neurotransmitter-related processes. It relies on making short-lived radioactive atoms that can be attached to a molecule of interest such as a drug and so identify its location within the brain with great precision.

MRI involves a group of technologies that use powerful magnets placed around the head to measure brain structures and blood flow with great precision and time resolution. Versions include functional magnetic resonance imaging (fMRI) and magnetic resonance spectroscopy (MRS). MRI does not use radioactivity so studies can be repeated a number of times in the same person.

Both these technologies have made major contributions to identifying the circuits involved in drug use and craving. PET has also demonstrated that certain neurotransmitter receptors, such as those for the endorphins, are abnormal in several forms of addiction and so may contribute to the disorder.

PET has the potential by 2025 to allow almost all the currently known neurotransmitters involved in addiction and their receptors to be measured. Doing this will require the collaboration of the biomedical industry. Industry has the molecules that can become PET tracers and which would form the basis for future progress in this field. The number of possible targets is growing rapidly and is already in excess of 60.

Future developments in producing biochemical tracers, coupled with patient research studies, could help to advance this area of the science.

MRI will improve as new technologies such as superconductors lead to stronger magnets, and from new techniques such as arterial spin labelling and hyperpolarisation. By 2025, 7 Tesla MRI machines should be routine equipment, allowing single-scan detection of brain activity. This would allow very sophisticated research questions to be addressed in a single session of several hundred scans.

MRS technology could be similarly improved, allowing fine-grain analysis of the activity of a couple of the key addiction-related neurotransmitters such as GABA and glutamate in the brain.

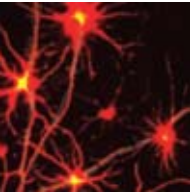
## **Drug testing**

There will be more sophisticated drug-testing procedures, but it will be harder to decide how best to deploy them.

Current technology exists to measure the presence of drugs in urine, blood, saliva, sweat and hair. The analysis of each has advantages and disadvantages. At one extreme is blood, which is best for predicting brain effects. But blood collection is difficult and needs trained personnel, is intrusive and runs the risk of infection. At the other extreme is hair testing which can detect drug use for up to a year but cannot give details of current or very recent use as there is a time lag before the drug enters the hair and the hair protrudes far enough from the skin to be sampled.

Current technology exists to test for most drugs of abuse and this could be extended to test for any new drugs, including prescription and over-the-counter preparations. Miniaturisation will lead to tests that are faster and can cover more drugs – perhaps up to 20 in a single assay – from sweat or oral fluid. But there is always a time lag in starting to develop a test for a new drug despite the technical simplicity of developing a test for a new target.

Precise on-the-spot quantification of drug levels to allow decisions on an individual's competence, for example, to use machinery, will probably not be possible even in 20 years. But tests of a person's functional performance may develop to the point where assessing a driver's ability in the face of a positive drug test is feasible. One current measure is the mismatch between the movement of the steering wheel and of the eyes in anticipation of the car turning. Such tests may begin to be incorporated into cars so that performance deficits lead to warnings or cut off the power. Smart cars and other machinery including planes and ships might be developed that will not work if drugs are detected. Tests for alcohol on breath are already being done experimentally and developments might include testing for drugs in sweat by inserting microdetectors into the surface of the steering wheel. (Though these could easily be foiled by wearing gloves.)



## **Future research**

The development of new drugs and research on the nature of and treatment for addiction are only the most obvious areas of innovation that could transform the field. Others include real-time data collection using the Internet, mobile phones and micro-chip monitoring, and analytical and telemetry technology to record environmental stimuli, drug intake, cognitive performance, physiological state and behaviour.

Future research on policy such as the effectiveness of different ways to control addictive drugs and behaviours to reduce harms and maximise benefits will continue to be needed.

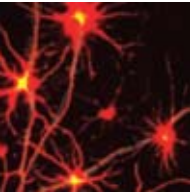
## **Box 5: Definitions of addiction**

It is difficult and probably counter-productive to attempt a single definition of 'addiction'. In practice, the term has been supplanted for clinical purposes by 'dependence'. Satisfying all the differing perspectives on the topic would lead to a definition that was so all-embracing as to be useless. The Diagnostic and Statistical Manual IV (DSM IV) of the American Psychiatric Association avoids the use of the term addiction and instead defines criteria for 'substance dependence'. It also describes a less severe syndrome of 'substance abuse'. Dependence is held to be a cluster of cognitive, behavioural and physiological symptoms indicating that the individual continues use of a substance despite its leading to significant problems. The definition includes a pattern of use that usually results in compulsive drug-taking behaviour, tolerance and withdrawal. In addition to the effect of any psychological compulsive drive to take more drugs, tolerance may contribute to the tendency to escalate doses. The wish to escape from the adverse effects of withdrawal can also be a potent motivational influence to continue to use.

Definitions of behavioural addictions have similar descriptions of continued compulsive behaviour, with loss of control and continuing in spite of negative consequences, such as for pathological gambling.

But in many cases it is unclear to what extent withdrawal and tolerance are necessary and sufficient conditions for a state to qualify as 'addiction'. The remaining element, compulsion to use a drug, is probably the key aspect of the definition. But what exactly does it mean, in the context of addiction? Some possible answers:

- taking more of the substance over a longer period than was intended
- unsuccessful voluntary attempts to desist from drug taking
- disproportionate time allocated to drug-related activities (including seeking, taking and recovering from them) so as to impact negatively on the individual's functioning in society through the neglect of other activities such as recreation, social life, education or work
- persistence in drug taking in the face of adverse effects such as physical or psychological harm, including recurrent disorderly conduct and crime.



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# List of publications: Drugs Futures 2025?

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