



FORESIGHT

Drugs Futures 2025?

Executive Summary
and Overview

OFFICE OF SCIENCE AND TECHNOLOGY

Contents

Foreword	1
Executive summary	3
Scope	3
Key findings	4
Why this matters now	4
The changing social landscape that forms the context for these advances	6
When do we need to take action?	7
What strategic choices do we face?	9
Overview	13
Introduction	14
What we did	15
Future psychoactive substances and their effects	17
Future medicines for mental health	17
Future treatments for addiction	20
Future so-called 'recreational' drugs	22
Future cognition enhancers	26
Future producers of psychoactive substances	28
Future producers of medicines for mental health	28
Future producers of cognition enhancers for the healthy	30
Future producers of so-called 'recreational' drugs	31

Contents

Changing social perception of psychoactive substances	33
Medicines for mental health	33
Medicalisation	33
Normalisation	34
So-called 'recreational' drugs	34
Perceptions of risk	36
Widening the definition of addiction	39
Factors affecting vulnerability to addiction	39
Managing psychoactive substance use	40
Management of treatments for mental health	40
So-called 'recreational' drugs	41
Modelling	43
Management of cognitive enhancers for the healthy	44
Drug testing	45
International issues	45
Testing public opinion	46
Individuals' rights versus society's rights	46
Prevention with drugs versus treatment for drug users	46
Community safety versus risk of a society with normalised behaviours	47
Scenarios	48
About Foresight	52
Acknowledgements	54
Glossary	56
List of publications: Drugs Futures 2025?	60

Foreword

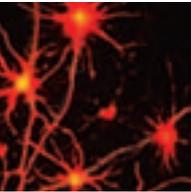


From the day we are born to the day we die, drugs help to keep us healthy, happy and strong. Over the next 20 years, drugs for mental health treatments are likely to be important to a growing proportion of the population, and legal and illegal so-called 'recreational' drugs will continue to have a significant impact on society at every level.

Though the changes we saw in the second half of the twentieth century were dominated by developments in computers and telecommunications, biology and medicine also made huge strides. The greatest changes we will see in the twenty first century may be brought to us through developments in our understanding of the brain. These advances may offer revolutionary treatments for the brain, and could see the end of neurodegenerative disorders such as Alzheimer's and Parkinson's Diseases. We should also see much improved treatments for addictions and other mental health disorders, and the development of new 'recreational' drugs some of which might lead to fewer harms and lower risks of addiction than the substances in use today.

Such changes are to be welcomed, but it is possible that we will also see fundamental advances of a new kind which will revolutionise the way we think. We are on the verge of developments which could possibly move us into a world where we could take a drug to help us learn, think faster, relax, sleep more efficiently or even subtly alter our mood to match that of our friends. This would have implications for individuals, and could lead to a fundamental change in the way we behave as a society.

But the brain is delicate. Anything we take can have unexpected and unwanted effects. Just as we may see new advances in the treatment of addiction, we could also see continuing use of existing and novel 'recreational' drugs. These drugs bring with them the potential for considerable harm with significant potential negative impact on individuals, families and communities. This is not a future we want to fall into unprepared.



This Foresight project provides us with the evidence for what future science may allow us to do in this area, and highlights the key opportunities and challenges of the next 20 years. It is essential that we use this information to decide the course we want to take as a nation, and take action to get us there.

Sir David King ScD FRS
Chief Scientific Adviser to HM Government
Head of the Office of Science and Technology

Executive summary

Scope

Over the last ten years there have been significant advances in our understanding of areas such as neuroscience, genetics, pharmacology, psychology and social policy. These advances have moved us to a new level in our understanding of how brains work, how chemicals affect the brain's performance and, in turn, how this affects our behaviour.

These advances may have wide-reaching implications for society over the next 20 years. They are likely to be applied in three key areas to provide a better understanding of:

- mental health and the development of new treatments for it
- the effects of legal and illegal so-called 'recreational' drugs¹ on different people and how to treat addiction
- mental processes, bringing with it the potential for substances that can enhance the performance of our brain in specific ways, such as improving short-term memory and increasing our speed of thought. This new breed of drugs is called cognition enhancers.

As with any advances that have significant implications for society, it is important to consider how to manage change before we find we have moved along a road we would rather have avoided.

This Foresight project was set up for precisely this task. Its aim was to consider:

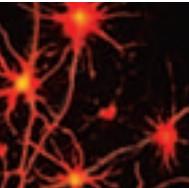
'How can we manage the use of psychoactive substances² in the future to best advantage for the individual, the community and society?'

This project was an independent analysis based on a thorough review of the science. The potential advances it uncovered were then explored in four different socio-economic scenarios to help understand the challenges and opportunities.

The findings do not constitute Government policy.

1 Legal and illegal so-called 'recreational' drugs are also termed 'recreational' drugs in this report.

2 A psychoactive substance is any substance or surrogate intervention that affects brain function through its chemical neurotransmitters. The term includes 'recreational', psychiatric, cognitive enhancing or mood altering drugs and also future technology such as trans-cranial magnetic stimulation or neural prosthetics.



Key findings

In the developed world, we live in an age where the majority find themselves in physical health and prosperity. As our material situation has improved, attention has turned more and more to our mental state. We do not expect merely to be well fed and housed. We also pursue happiness for ourselves and others. At the same time, we expect more from our brains. As citizens of the knowledge economy, we can access trillions of facts through our fingertips.

Our knowledge of the way human brains and behaviour work has been growing apace. This knowledge has brought significant gains through better treatments for many mental health disorders and the diagnosis of new conditions such as Attention Deficit Hyperactivity Disorder (ADHD).

Over several decades these factors have contributed to the increased use of chemicals to affect our brains. We term these 'psychoactive substances'. The volume and range of so-called 'recreational' substance use in the UK is growing and there has been an increase in the use of medicines for mental health. Most recently there has been an increase in interest in cognition enhancers, chemicals intended to optimise the performance of a specific function of the brain.

We are on the verge of a revolution in the specificity and function of the psychoactive substances available to us. In particular, we expect to know far more in the near future about their effects on individual users. This report seeks to map out future landscapes for psychoactive substances and their use. It highlights the routes we could take and the hazards and opportunities we can avoid or embrace. We need to decide how to use the map to find the best way forward, rather than letting the journey unfold before us. The challenge is that every advance will bring risks, so there are no easy choices.

Why this matters now

There has been significant investment in research in this area and it is starting to bear fruit. Many of the advances have been unexpected and are still not understood. But they suggest that we are on the verge of major change.

New approaches are being developed for medicines for mental health

- Preventative treatments are being trialled for Alzheimer's Disease and we may be able to develop them for schizophrenia.
- Pharmacogenetics is allowing us to identify people at higher risk of adverse side-effects.

- We are learning more about how the brain regenerates itself. This may play a key role in helping us to treat mental health disorders and reduce natural mental decline with age.

There have been significant advances in our understanding of addiction and our understanding of the treatments available for it

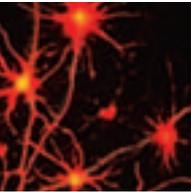
- The amount of information on the harms of 'recreational' drugs is increasing. We may be able to use this growing body of evidence to help us to make better decisions about our 'recreational' use of them. For example, it is clear that children and adolescents are much more vulnerable than adults to harm and addiction.
- Drugs are being developed which help people to forget experiences. In the future it might be possible to 'unlearn' an addiction.
- Vaccines are being trialled that might allow us to stop the action of specific 'recreational' psychoactive substances on the brain.
- Genomics is helping us to identify why certain groups of people are at greater risk of harm from 'recreational' drugs than others. This could allow treatments to be targeted more precisely.
- A drug has been found that can block the memory-impairing actions of alcohol in humans.

New types of so-called 'recreational' psychoactive substances are being developed

- Scientists have been able to separate the effect of one psychoactive substance from its addictive properties. This could pave the way to non-addictive 'recreational' drugs, but as with any new substance the risks will need to be assessed also.
- A psychoactive substance has been developed that reduces the side-effects of 'recreational' drugs. Such compounds might allow users to shape their drug experience.
- Scientists believe that they could produce a 'recreational' substance with similar effects to alcohol but fewer harms.

New psychoactive substances are being developed which improve the performance of the healthy brain

- Modafinil was developed as a treatment for narcolepsy (a sleeping disorder), but it has been found that it allows healthy individuals to stay awake for up to three days. It is not yet known if there are long-term side-effects.



- Recent work on the effects of ampakines, a type of molecule that enhances the working of some brain receptors, suggests that drugs could be developed to improve the memory of the user under conditions of fatigue.

The changing social landscape that forms the context for these advances

These advances will be set against a backdrop of new expectations and social views.

There is a large unmet need for medicines for mental health. It is set to increase as the population ages and with improvements in diagnosis. The increasing need and the rise of the 'consumer patient' will keep pressure on Government to find treatments for mental health disorders and for the natural decline of mental capabilities with age. There is an increase in self-treatment as people buy medicines online and use alternatives such as natural health foods and 'healthy options' food lines. There is a blurring of the distinction between medicines for mental health and foods.

Behaviour can become medicalised as we increase our understanding of its root cause and recognise certain behaviours as medical conditions. It is not clear how far this will go. We have already seen excessively active children diagnosed as having ADHD and excessively shy people being diagnosed as having social anxiety disorder. Effective treatments have been made available for both conditions.

We can see a trend in the normalisation of the use of medicines for mental health treatments in some areas such as the control of mood, but also an increasing concern about the risks of new medicines. We accept far less risk with new drugs than with some drugs already available over the counter. And there is an increasing expectation that there is a pill to solve every problem.

Pharmaceutical companies are under increasing pressure to reduce prices, while discovery and development costs are soaring. It costs in the order of \$1 billion and takes ten years to develop and approve a drug. Pharmaceutical companies could withdraw from the development of new medicines for mental health.

It is undisputed that substance misuse can lead to significant harm to individuals, families and communities. Misuse of 'recreational' drugs has a significant social and economic cost on society. It is estimated that the current total economic and social costs in the UK are in the order of £13bn a year. The largest part of this relates to the estimated social costs associated with the victims of crime. Health harms are significant with around an estimated 350,000 problem drug users in the UK. Many of these are injecting users and therefore are at a risk of transmitting hepatitis C and HIV infections. A report – "Hidden Harm" – illustrates the impact on families with an estimate of more than 100,000 children in England, Scotland and Wales with a mother who is a problem user.

We can see continued use of 'recreational' psychoactive substances and greater sophistication in the way people are using them. Better information is allowing users of such drugs to create the experience they want by combining existing and novel substances in new ways. This could lead to significant increased risks, for example, we know that certain combinations can increase harms significantly. On the other hand, better informed use could lead to less risk.

The size of the market for treatments for addiction is small and there is a potential for stigma to be attached to any business that might develop treatments for illicit drugs. So, although the impact of addiction on society is significant, pharmaceutical companies have little incentive to develop treatments for addicts to illicit 'recreational' drugs.

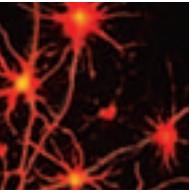
In the future there could be increasing expectation that the regulatory structure for 'recreational' psychoactive substances matches our understanding of their harms. Decisions on the regulatory approach to 'recreational' drugs must take into account:

- the harms (to the individual and others)
- the benefits
- the aims of policies, which affect the weight we give to the importance of different harms and benefits
- society's view (including the ethical perspective) of the acceptability of the substance
- people's rights to use a substance that is currently legal.

We are starting to see the use of cognition enhancers by the healthy. They are developed for health treatments and then found and used by healthy people. For example, methylphenidate (known as Ritalin), a treatment for ADHD, and modafinil, a treatment for narcolepsy, are being used to improve alertness and performance by groups including a small number of students. Both of these drugs are licensed for use on prescription only. Based on current knowledge modafinil does not appear to have any negative side-effects, a key feature if a psychoactive substance is to be used by healthy people. The most recent addition to this list are ampakines, a group of molecules which appear to improve alertness.

When do we need to take action?

Though the effects of these changes are uncertain and some may be far in the future, we need to take action now if we are to manage the risks.



Medicines for mental health

Continuing too long with current frameworks could create a risk that the pharmaceutical industry pulls out of the market for the development of new medicines for mental health. We may see an increase in self-treatment, with individuals using approaches that are outside the normal regulatory safeguards. We may also see new conditions diagnosed and treated, shaping the acceptability of new patterns of behaviour in society, without a full dialogue about the consequences of such changes.

'Recreational' psychoactive substances

Future approaches to the management of 'recreational' drugs require solid information and time to engage in a dialogue with the public before change. One strong message from our analysis is that any change to the legal status of a 'recreational' drug could lead to unexpected negative effects if society is not ready for it. Reducing harm from the use of 'recreational' drugs is as much about having the right culture for their use as it is about the policy for their management, for example, responsible drinking of alcohol rather than binge drinking. This is important whether we are increasing or decreasing the level of control. If management of the use of a specific substance is tightened, users may try to find a way around the change, which can lead to other forms of harm. But if controls are lessened without a culture that supports sensible use of the substance, an increase in harm can also result.

It will always be important to respond quickly to new harmful patterns of use of 'recreational' drugs, ideally to allow intervention before those patterns become embedded in culture. Developing mechanisms which can look for and identify harmful new patterns early will be important to achieve this, as will the creation of a dynamic regulatory structure that can be adjusted as clear new evidence emerges.

It takes ten years to develop and clear for use a medicine for mental health, from discovery of the molecule through clinical trials. This would apply to drugs to treat addiction. To ensure there is an investment in treatments for addiction, we could seek to create the market conditions for their development, or try to support advances in science or clearance procedure to reduce development costs.

Cognition enhancers

If we ever found ourselves in a society that embraced cognition enhancers, 'mental cosmetics' could become accepted and create new expectations about the performance and behaviour of individuals and groups. Policies in such a situation should seek to minimise harm and also to consider the social and ethical issues. We would need to understand the risks of the cognition enhancers that were in use to regulate them effectively. In that event, we would also need to consider what role the UK pharmaceutical industry might play in this market.

What strategic choices do we face?

We are faced with a number of difficult and sensitive choices. There are no simple decisions as each option includes advantages and disadvantages. In some areas it is not an either or, it is more finding the right balance between competing goals.

Tables ES1–3 set out the main choices we face. All these issues will need to be considered in a global context.

Table ES1: MEDICINES FOR MENTAL HEALTH

Accept greater risks from the use of new medicines for mental health in order to encourage innovation in their development.	vs	Maintain high expectations under the clearance process for new medicines for mental health, which would reduce the risks of harm from their use, but in the long term risk the withdrawal of the pharmaceutical companies from this market.
Allow the continual evolution of the definition of behavioural conditions and increase in treatments for 'healthy' people. The risk is that we might end up in an unhealthy, over-medicated society.	vs	Take a medical decision on the line between someone who is ill and someone who is not. The difficulty is deciding where that line should be.
Accept withdrawal of the pharmaceutical industry from the development of new medicines for mental health for children and youth.	vs	Find new approaches to research and development on medicines for mental health for children and youth.
Accept the trend in the normalisation of use of medicines for mental health, which risks creating a drug-dependent society. This risks providing medicines for mental health when an alternative would be better and more sustainable.	vs	Seek to discourage some use of medicines for mental health and encourage other forms of treatment. This risks creating a culture opposing the appropriate use of medicines for mental health.
Try to develop a society conducive to mental health. But our interventions might worsen the situation.	vs	Accept the mental health consequences of social change. The risk is that we could find ourselves locked into unsustainable situations.
Ensure that all food and drugs with medical aims are consistently regulated. This process could be disproportionate.	vs	Accept different approaches to the regulation of food and drugs for which similar claims are made. This could lead to health risks for users of untested products with health claims.
Accept self-treatments for mental health conditions.	vs	Find a response to self-medicalisation.

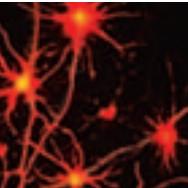


Table ES2: SO CALLED 'RECREATIONAL' PSYCHOACTIVE SUBSTANCES

Consider whether the public sector should have a role in the development of treatments for addiction.	vs	Accept the risk that new treatments for addiction are only likely to arise as 'spin-offs' from the development of medicines for mental health.
Allow individuals to have information on their vulnerability to addiction and let them decide what action they will take in response to it.	vs	Use new information on vulnerability to inform the approach to management, including the use of vaccines. The risks are that information on vulnerability will not be absolute and use of preventative measures would need to be balanced with the risks of their use.
Explore the development of less harmful alternatives to current 'recreational' drugs and their introduction as substitutes for them.	vs	Use existing methods to seek to reduce harm from the use of 'recreational' substances.
Support the development and introduction of drug quality tests which individuals can use to check the substance before use. There is a risk of apparent acceptance of use of certain illicit drugs.	vs	Accept the safety risks of individuals using recreational substances from unknown sources and use education to discourage their use.
Seek to use conventional methods to watch for the behavioural impacts of the use of drugs and accept the safety risks if those methods do not work.	vs	Support the development of tests for psychoactive substances for use in workplaces and schools to ensure safety and fairness. Face concerns about an individual's rights to privacy for their information and the development of new substances to fool the tests.
Seek to understand the underlying social drivers of the use of 'recreational' substances and take steps to change the social situation. This might involve looking at culture, diet and environment. This is difficult and calls for a long-term approach. The changes made could create new risks.	vs	Deal with 'recreational' substance use through existing regulations that seek to modify behaviour by making drugs harder to get, increasing the risks associated with their use by criminalising them, and providing information on harms.
Wait until significant problems emerge and then focus resources on those issues. This risks allowing harmful use to become embedded in society and making it more difficult to respond to.	vs	Seek to identify as early as possible any emerging threats, including new drugs, new modes of delivery or new cultures of harmful use. While there is value in knowing what is on the horizon, it is difficult to know which emerging issues will be important and how to respond in order to dampen rather than fuel the problem.

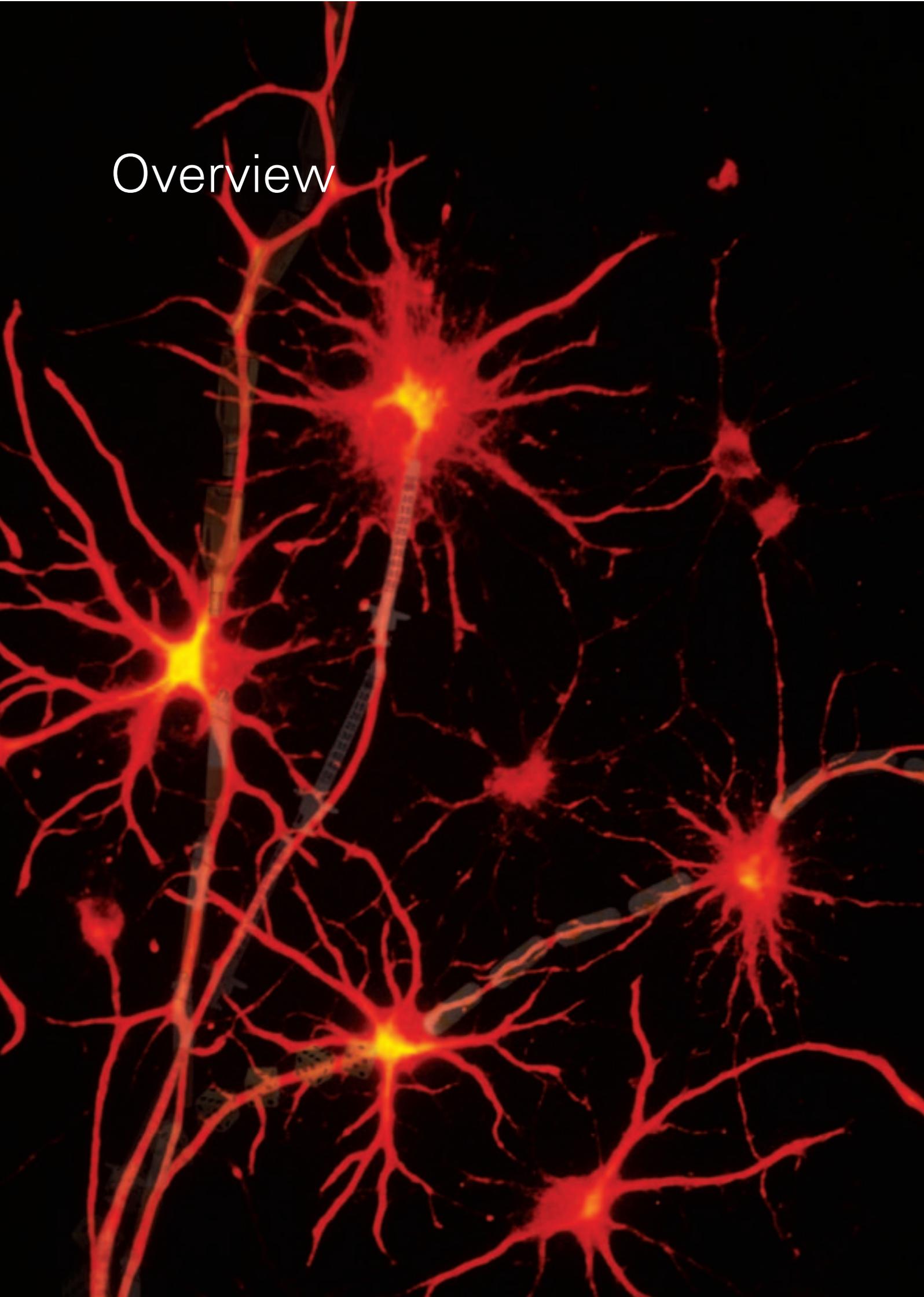
**Table ES2: SO CALLED 'RECREATIONAL' PSYCHOACTIVE SUBSTANCES
 (continued)**

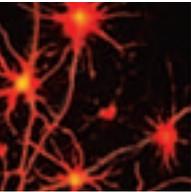
<p>Adopt a harm-based approach to the way we regulate 'recreational' substances. This would make it easier to compare substances and apply rules that appear consistent.</p>	<p>vs</p>	<p>In addition to harm, take account of the wider social context and ethical issues and benefits from the use of psychoactive substances when we decide the approach to management of each 'recreational' psychoactive substance. This makes decisions and communication of those decisions difficult. It means that policies will evolve to reflect the changing values of society.</p>
<p>Seek to promote the individual's responsibility to society in decisions on 'recreational' substance use.</p>	<p>vs</p>	<p>Accept the increase in support for the rights of an individual to use 'recreational' psychoactive substances if they choose to do so.</p>

Table ES3: COGNITION ENHANCERS

<p>Accept the natural evolution of the use of cognition enhancers by healthy individuals. This risks taking us to a society dependent on these substances, with haves and have-nots and potential negative long-term consequences for the mental health of the nation.</p>	<p>vs</p>	<p>Start a discussion on what view we should take as a society of the use of cognition enhancers by the healthy. Then decide what management approach to put in place to reflect that view.</p>
<p>Seek to support UK business to take early action to capture a share of this market. This risks a pre-emptive decision about what UK society wants.</p>	<p>vs</p>	<p>Let others benefit from commercial developments in this field.</p>

Overview





Introduction

Over the last ten years there have been significant advances in our understanding of areas such as neuroscience, genetics, pharmacology, psychology and social policy. These advances have moved us to a new level in our understanding of how brains work, how chemicals affect the brain's performance and, in turn, how this affects our behaviour.

These advances will have wide-reaching implications for society over the next 20 years. They are likely to be applied in three key areas to provide a better understanding of:

- mental health and the development of new treatments for it
- the effects of 'recreational' drugs on different people and how to treat addiction
- mental processes, with the potential for substances that can enhance the performance of our brain in specific ways, such as improving short-term memory and increasing our speed of thought. This new breed of drugs is called cognition enhancers.

As with any advances that have significant implications for society, it is important to consider how to manage change before we find we have moved along a road we would rather have avoided.

This Foresight project was set up for precisely this task. Its aim was to consider: 'How can we manage the use of psychoactive substances in the future to best advantage for the individual, the community and society?'

This project was an independent review based on a thorough review of the science.

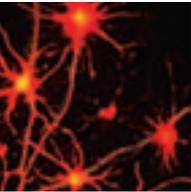
What we did

In order to answer that question:

- Fifteen reviews of the science – from neuroscience to sociology – were produced by leading scientists in the fields. Each of these reviews looked at the current understanding of the science and also what future capabilities science might offer:

Drug testing	Economics of addiction and drugs
Genomics	Social policy and psychoactive substances
Life histories and narratives of addiction	Cognition enhancers
Pharmacology and treatments	Neuroscience of drugs and addiction
Experimental psychology	Neuroimaging
Sociology and substance use	Psychological treatments of treatments of substance misuse and dependence
Ethical aspects of developments in neuroscience and drug addiction	History and the future of psychoactive substances
Problem gambling and other behavioural addictions	

- The reviews were all peer-reviewed by independent experts and their remarks reflected in the final versions which the project has published.
- We picked out from these reviews the key advances which are likely to affect future psychoactive substances and their uses. These findings were turned into a document called the *Horizon Scan*, which looks across all areas of the science relevant to the question above.
- We worked with a wide range of people who have interests in the field of psychoactive substances, to develop a set of scenarios that explored four different futures we might face.
- The pharmaceutical and biomedical companies provided their views on the potential advances that they thought they would be able to deliver and the challenges they face in doing so.
- We ran a series of workshops with members of the public to seek their views on how society might react to the potential advances.
- A small group of experts in modelling reviewed the current capability of models to help us take good decisions on policy change in this area, considered the advantages and disadvantages of the different types of models, and suggested



the types of information we would need to collect if we wanted to use those models to inform decisions.

A list of publications is at the back of this report. Copies of the full reports are available from the Office of Science and Technology. Copies of the publications can also be downloaded from the Foresight website (www.foresight.gov.uk)

It is not possible to cover all of the advances we discussed, and their potential consequences, in this overview report. This section describes the key issues the UK is likely to face and highlights some of the strategic questions we will need to address over the next 20 years in this area.

The remaining sections of the overview cover:

- the future of psychoactive substances and their effects
- the future producers of such substances
- changing social perceptions of them
- implications for the future management of psychoactive substances.

Future psychoactive substances and their effects

Psychoactive substances have always been an integral part of society. Even 6,000 years ago, the Egyptians brewed beer. For centuries, we have been using birch bark (which contains salicylic acid, the active ingredient in aspirin) as a medicine. For millennia, people have been using psychoactive substances in religious rituals. While the third of these reasons for taking psychoactive substances has declined, there has been significant growth in the types of substance available for the treatment of mental health and for 'recreational' use. A quick look down the drinks aisle of a supermarket confirms these developments and shows how embedded in our culture and expectations they have become.

In this section we review our key findings on the ways that we will use psychoactive substances in the next 20 years for their 'recreational' purposes, their medical properties and, in a new departure, their scope for enhancing our mental performance.

Future medicines for mental health

Treatments for mental health are likely to develop in a wide range of areas (see Table 1). New treatments are likely to be available for Alzheimer's and Parkinson's Diseases and for schizophrenia. There will be new treatments for stress, depression, anxiety, and to improve sleep. There are likely to be new descriptions of mood disorders and new treatments for them.

The research community is looking at the potential for new treatments that use chemical pathways in the brain not targeted before, such as drugs that affect glutamate, the brain's most widespread neurotransmitter. Its generality makes it difficult to confine the effects of a drug to a particular action without side-effects. But recent research has found that there are a number of modulators of the operation of glutamate. These are found in different parts of the brain, potentially allowing the development of drugs with specific effects upon the operation of the glutamate system.

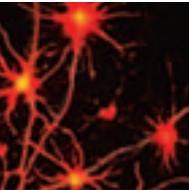


Table 1: Business forecast of the delivery of new types of treatments

	5 years	10 years	15 years	20 years	never
Vaccines	—————	—————			
Cognition enhancers	—————	—————	—————		
Unlearn addiction					?
Anti-craving		—————	—————		
Anti-stress	—————	—————	—————		
Pain killers – non-addictive	—————	—————	—————		
Anti-anxiety	—————				
Anti depressants		—————			
Sleep disorders	—————				
New descriptions of mood disorders leading to new treatments			—————		
Drugs for children					?
Drugs for old	—————	—————			
Non medical use					?

Source: Report: Foresight Drugs Futures 2025? Perspective of the pharmaceutical industry.

Other potential drug targets include a range of neuropeptides involved in the operations of the brain. Key challenges in their development remain. They include:

- the lack of molecules that can be used as markers to improve understanding of the mechanisms of these chemicals
- the lack of animal models of mental illness
- the lack of objective tests for the diagnosis and assessment of mental health disorders.

Given the difficulty of developing drugs that act on the brain's communications systems, other avenues are being pursued, such as the direct electrical stimulation of certain regions of the brain (an effective treatment for Parkinson's Disease which is beginning to be used in depression) and the use of stem cells to enhance parts of the brain that are underdeveloped or damaged. One company recently trialled antibodies as a treatment for Alzheimer's. The antibodies bind to amyloid, whose build up in the brain is thought to lead to dementia. The approach was very effective in clearing the amyloid from the brain, but had adverse side-effects in clinical trials. New vaccines are under development. These avenues may all produce significant advances in future treatments.

Neurogenesis, the possible growth of fresh brain material, is a controversial area of research that may provide opportunities for rapid advance in our understanding and treatment of mental health. Recent studies on depression illustrate this. A number of treatments for depression work by raising the levels of serotonin in the patient's

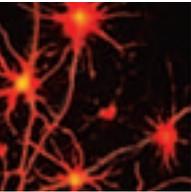
brain. At first it was thought that levels of serotonin were the determinant of depression. Now it appears that the serotonin may protect the brain by allowing it to repair itself through growing more nerve cell connections or even new brain cells (a process called neurogenesis). Growing understanding of neurogenesis may open the way for new forms of drugs to treat moods.

The use of an individual's genetic information to decide on the appropriate therapy (pharmacogenetics) is also likely to have a major impact on treatments of the future within the 20-year timescale of this project. There are significant ethical issues to be debated in this area. The ultimate goal for pharmacogenetics is to design a therapeutic drug for the individual. It has been recognised, though, that an array of complex factors, both genetic and environmental, affect the performance of the brain. This makes it very difficult to develop personalised solutions for the majority of individuals and conditions. This does not mean that pharmacogenetics is a lost hope. It has helped us to understand why some people suffer side-effects to some drugs and not others. Information on our genetic profile may in the future: reduce the number of people who suffer from side-effects as they take drugs; increase the chance of the patient getting the most appropriate drug; and enable new treatments to be developed. It should enable better clinical trials and the return or development of some substances that were effective but had previously been abandoned because of negative side-effects for some members of the population.

Behavioural and cognitive therapies are increasing in importance with the growing recognition that we need to treat the individual's psychology and not just their physiology. In the future, we may see a growing use of mental exercises and the creation of the right environment to support the development of a healthy brain. We are likely to see more therapies that combine psychological insights with psychoactive substances.

A case in point is depression. Over the last ten years there has been a significant increase in the number of people suffering from depression. This may be partly because of better diagnosis and increasing openness about the condition, as it is more widely accepted and effective treatments are more readily available. But there may be other changes in society that are partly responsible for this increase. As we search for an answer, there is growing interest in how to support the development of a healthy brain. Areas that are being looked at include mental exercises, our environment and diet.

Our brains remain flexible throughout life, and within limits, the more we use our brains for a particular task, the more its performance in that area develops. This is why certain mental activities can help to delay the deterioration of the brain's performance as we age. In the future, this knowledge is likely to affect our education programme. There may be games for children that develop their brains to have greater capacity in later life.



There is also evidence that our environment affects the development of our brain, from the languages we learn to the types of visual stimulation we experience. Depression is often triggered by stressful experiences and people have different levels of resilience to stress. This may be caused by varying levels of robustness of the hippocampus, an area of the brain that is also involved in memory. Small amounts of stress during development increase its resilience in later life. As we learn more about these factors, we may be able to provide advice on the environment which will best prepare our brains for the stresses of modern-day life.

The impact of diet on the performance of our brains is well established. Sugar is the most common food that can have psychoactive effects. There is evidence that if an individual who is susceptible to depression does not eat enough food containing tryptophan (such as in cheese and yoghurt), the precursor to serotonin, they can relapse into depression. It is less clear how diet affects the development of the brain.

There is also a trend towards blurring the distinction between food and drugs for mental health. There is an increase in the number of foods and herbal supplements claiming to improve mental and physical health, though the evidence for many is far from clear. The increasing interest in the use of such foods reflects a trend in society towards self-medication and a desire to use more natural health treatments. These trends may mean that more supplements will be included in foods to improve mental performance, or to protect against mental decline. Nicotine is being studied as a possible inhibitor of Alzheimer's, and it could become a supplement in certain foods for older people.

At the extreme end of science, there might also be the incorporation of psychoactive substances into foods. Potatoes have been developed that produce the hepatitis vaccine. In the future, could potatoes be developed containing precursors to neurotransmitters, or perhaps a drug such as modafinil to support better decision-making?

Future treatments for addiction

There have been significant advances in our understanding of the changes that occur in the brain when someone becomes addicted. When we make decisions, four areas in our brain are normally brought into play: those regulating behavioural control, reward, motivation and memory. It is thought that the normal balance between these processes is disrupted in addiction, leading to impaired judgement and the repetitive use of drugs in the face of damage to the person's health and welfare.

In the future, it is possible that we will see the development of new approaches to prevent addiction, as well as new treatments for addiction that seek to address

the changes that occur in an addict's brain in all four of these areas. Cognition enhancers may become available that help to reactivate control and break the drug-seeking cycle. Vaccines that bind to the active part of the drug molecule may allow us to eliminate reward from taking drugs. We may have psychoactive substances that help addicts 'unlearn' addiction and, perhaps in combination with motivational therapies, strengthen their resolve to stop. Any decisions to use these would need to consider the ethical issues.

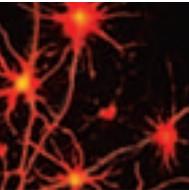
When someone becomes addicted, it is thought that the links to the brain's control centre are weakened or broken. The individual is then locked into a self-reinforcing cycle of drug-seeking behaviour. It also appears that people who are more vulnerable to addiction tend to be those who are less good at planning. With new drugs and psychological approaches, it might become possible to reduce the risks of an individual becoming addicted to drugs by improving their abilities to plan.

Vaccinations are already being developed for people who smoke cigarettes. There are two potential types, antibodies that are injected into the body and remain there for about a month, and preparations that create an immune response in the person. In the latter the body's own defence system produces the antibodies to bind with the drug and 'mop it up' whenever it is taken.

We have already seen the use of beta-blockers to help people forget or better manage their traumatic experiences. We may see drugs to help us 'forget' an addiction. Therapeutic drugs that have abuse potential may in the future only be produced when combined with a 'forgetting' drug to reduce the risks of addiction. This would follow the precautionary approach we have seen with the inclusion of an antidote in some paracetamol tablets to prevent liver damage from overdose. Drugs to 'forget' might also be used to break the link with social clues that trigger drug-seeking behaviour, for example, the sight of a bar for an alcoholic or a casino for a gambler. There may also be potential for such drugs to be used to manage craving and relapse in drug addicts.

We might also improve on current motivation and cognitive therapies. This is a field that is also being driven by the need to treat mental health conditions.

It is unlikely that any of these approaches whether drug based or psychological will produce a perfect solution on their own. It is likely these would need to be combined to meet the needs of the particular individual. These could build on work such as the US use of psychedelic drugs in combination with psychological therapy to treat addiction. There were reports of quick successes with such combinations. The US is investing in research on the value of such combinations as treatments for post-traumatic stress. The drugs may make the user more able to relive the past trauma, allowing the issues to be faced and resolved.



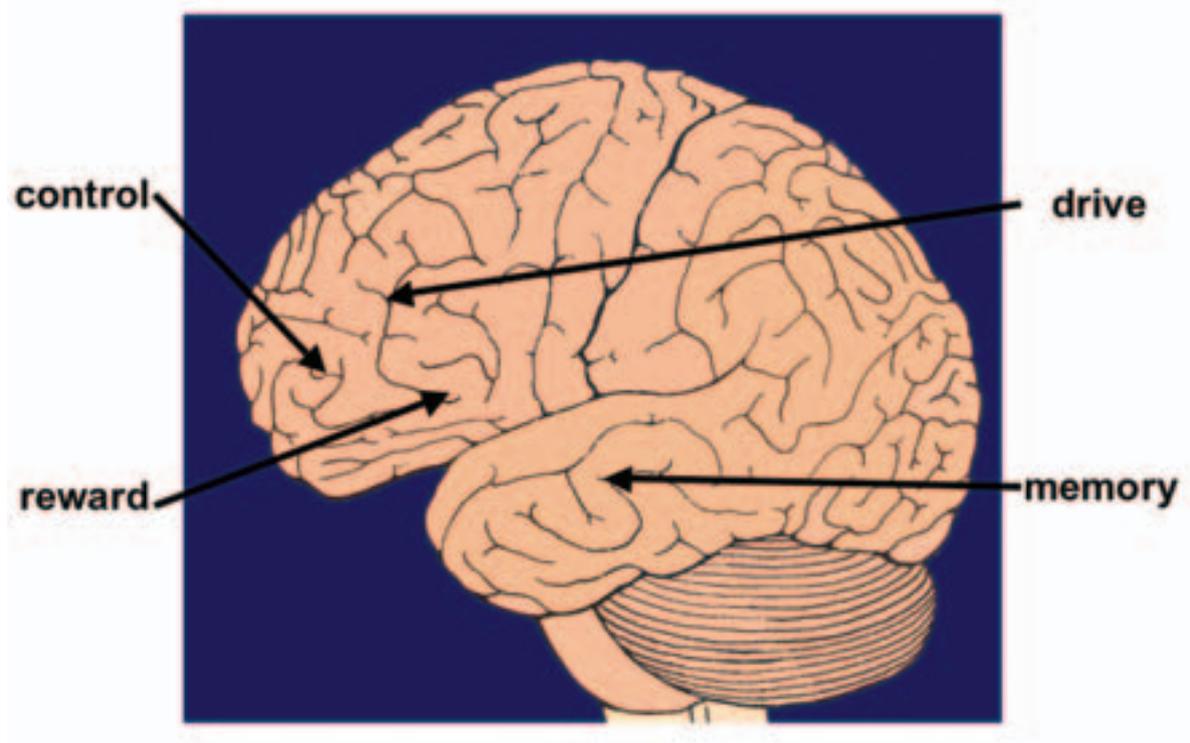
Issues for consideration?

Brain science is progressing rapidly. One exception is the development of new ligands (i.e. tracers) to allow us to attach visual markers to track the activity of molecules in the brain. We only have a limited range of ligands at the moment, mostly for the dopaminergic system. These few have brought significant advances in our understanding of the operation of the brain and the processes of addiction. The development of ligands for the other key neurotransmitters – serotonin, glutamate and acetylcholine – could deliver a significant step-change in our understanding of the operation of the brain.

The future of so-called 'recreational' drugs

Our brains are wired to find ways to improve our situation. Any perceived positive change in our situation is rewarded and any negative change in our situation leads to anxiety and stress. Psychoactive substances offer ways to stimulate this reward mechanism or to dampen anxiety and stress (see Figure 1). It is inevitable that psychoactive substances will continue to be used in society.

Figure 1: Brain sites of the component processes in drug addiction



Source: D.J. Nutt

Over the past 40 years use of 'recreational' drugs has increased, reflecting a long term upward trend. However, recent information raises uncertainty about the future direction of the trend. For example, use of tobacco in the UK has gone down and the most recent surveys in Scotland on heroin picked up a decline in its use between 2000 and 2003. So, it is not possible to know whether substance use and misuse will increase or decrease over the next twenty years. But, given the significant potential harms to the individual, community and society from 'recreational' drug use, continued effective management is needed to ensure that we do not see levels of use in the future follow the long-term trends of the past.

Examples of indicators that make future levels of drug use unclear include:

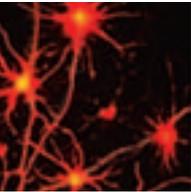
- Female use is not as high as male use
- Rural use is lower than use in the cities
- People are taking drugs earlier in their lives
- People are continuing to use drugs later in life.

Whatever the ultimate levels the harms caused by the use of 'recreational' drugs will continue to have a significant negative impact on society in terms of crime, public health and effects on the economy.

Many of the 'recreational' drugs of today will be those that society will continue to use in the next 20 years. This includes tobacco and alcohol as well as illicit drugs such as amphetamines, cocaine, heroin and cannabis. But there are also likely to be new synthetic 'recreational' substances. There are four key potential sources for these new compounds:

- new learnings about neuroscience – we now know of more than 60 chemicals that have a role in the operation of the brain
- databases of small molecules that have the potential to have an effect on the brain
- substances developed for clinical use
- illicit laboratories.

Some of these new products could provide similar effects to current substances but with a reduction in their potential to cause harm. Thus, a benzodiazepine receptor partial agonist could act as a safer alcohol. Others may bring new risks and be more addictive than current substances, as the introduction of crack cocaine has shown. We may see an escalation in the race against new drug-testing technology, with new synthetics developed that have effects like those of existing drugs but which are, at least temporarily, undetectable and have yet to be made illegal.



There may also be new drugs that shape the experience of the user. A recent example of such a drug is rimonabant, which is used to help weight loss and to stop smoking. It acts as an antidote to the sedative effects of cannabis and may have actions on the use of, or withdrawal from, other drugs such as heroin. Scientists have also found a chemical that will block the memory-impairing action of alcohol and which could be self-administered by drinkers.

The balance of the amounts of these drugs that are used is likely to change over the next 20 years. The level of use of each of these drugs will vary with social views of their acceptability, information on their effects, fashion, and the way their use is managed. The balance of use will vary within countries, just as it will vary internationally according to cultural context.

We are likely to see drugs combined in new ways as users gain a better understanding of the effects of combinations of drugs. A historical example of a dangerous combination was the 'purple heart' pill, which was a medicine combining an upper and a downer. The upper increases energy and alertness, but this could be accompanied with anxiety. The downer was a relaxant but the user sometimes falls asleep. The combination sought to combine and optimise the benefits of both – a mellow and relaxed feeling of energy, without falling asleep. A more recent example of a combination comes from Iceland where it is reported that the abolition of licensing times led to bars staying open all night – and to drinkers taking a stimulant drug so that they can stay awake longer to drink alcohol. In the future, could we see a combination of a cognition-enhancing drug with alcohol, to support more careful decisions with alcohol? The drinker could enjoy alcohol but would still think clearly. They might stop drinking earlier and perhaps think about the consequences before punching someone.

Combinations of drugs can also mean new risks. For example, cocaethylene, which is highly toxic to the liver and heart, is produced when the body breaks down cocaine and alcohol at the same time.

We can see continued use of 'recreational' psychoactive substances and greater sophistication in the way people are using them. Better information is allowing users of such drugs to create the experience they want by combining existing and novel substances in new ways. This could lead to significant increased risks, for example, we know that certain combinations can increase harms significantly. On the other hand, better informed use could lead to less risk.

The Internet may become a more important source of information on the types and effects of 'recreational' drugs. Over the next 20 years, genomics may provide individuals with a better understanding of the effect that a 'recreational' drug will have on them, perhaps alerting individuals to a high level of risk of harm from particular drugs, or the safe dosage to use. It may also provide information on an individual's risk of addiction to a range of 'recreational' drugs. Although any

decisions to use genomics in this area would need to be subject to a wider ethical and social debate. New drug tests may allow individuals to monitor the amount of a drug in their system in real time and its probable effect on their behaviour and performance, allowing safer self-regulation of drug use.

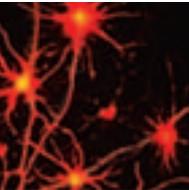
Drug tests are likely to be cheaper, simpler and more mobile. Tests might check the strength of an alcoholic drink and provide the user with an indication of whether consuming the product will provide them with a small health-enhancing dose or a hazardous amount of alcohol. The technology may also allow us to check whether food or drink has been spiked.

More controversially, the tests might be used to check for the purity of 'recreational' drugs such as ecstasy. If such technology were available should it be legal to use it? Such techniques could reduce the harm from using 'recreational' drugs. But making drug use safer and giving drugs tests official legitimacy could encourage the use of illicit substances.

We may see 'recreational' substances taken in new and potentially more harmful ways. The way that drugs are taken has a significant effect on the user. Any device that opens the way for the active ingredients to get to the brain quickly will produce a faster 'hit' and a bigger 'high'. But it will also increase the potential for addiction and poses a risk of death. The hypodermic syringe brought benefits to healthcare but also had a profound effect on the way drugs were taken. Direct delivery into the blood stream gave a quicker 'hit', making this mode of consumption much more addictive. It also opened the way for blood-borne disease to be passed between users. The advent of flue-dried tobacco and machine-made cigarettes opened the way for the widespread take-up of smoking by women.

There are a number of new and developing technologies that could be used to deliver drugs in new ways. Examples include patches, vaporisers, depot injection and direct neural stimulation. Patches are already used as a treatment for addiction and there are clear economic drivers that will lead to the continuing development of this technology. This may encourage the development of technology for the slower release of 'recreational' psychoactive substances, which could reduce the risk of addiction.

Under-the-tongue sprays have been developed for the therapeutic delivery of cannabis. They could allow people such as Multiple Sclerosis sufferers to use cannabis without the risks of respiratory problems caused by smoking it. But the vaporiser delivers the drugs quickly into the blood stream through the capillaries in the mouth, so vaporisers could become a new mode of drug delivery that delivers quick highs and is more addictive than existing technology. Delivery technology should be tracked partly for its possible benefits, where it allows drug delivery to be less addictive or dangerous, and also to reduce the chances of inappropriate use.



Future cognition enhancers

It is likely that we will be able to produce a wide range of cognition enhancers. They will be used as mental health treatments, and may be used more widely by healthy people to optimise their mental performance. They may have an important role to play as treatments for addiction.

Cognition enhancers are likely to be developed to treat people who need to improve attention, memory, planning or wakefulness and to help people to forget, sleep more efficiently and be less impulsive. We have already seen advances in this area. Modafinil has been introduced to treat narcolepsy, while beta-blockers help reduce unpleasant memories from stressful situations.

Cognition enhancers may also help treat addiction by improving addicts' ability to plan, decreasing the chances that someone will become addicted and helping to re-establish an individual's control over their use of a substance.

Cognition enhancers that allow people to forget might help return the brain to the state that it was in before the individual became addicted to a psychoactive substance. Such drugs might also be used to remove cues the individual associated with the use of a drug. So drinking with friends might no longer create a trigger for an individual to smoke tobacco.

It is possible that such an advance could usher in a new era of drug use without addiction. As psychoactive substance misuse is very likely to continue to lead to significant harms, such an advance could bring considerable benefits. But advances such as this are not without risks. These raise significant ethical, social and practical issues.

The potential uses and abuses of a tool that would allow people to forget have been examined in a number of films, such as *Total Recall*, or most recently *The Eternal Sunshine of the Spotless Mind*, where characters are able to forget about painful relationships. This highlights the social issues of such advances, such as the importance of holding on to some memories so we do not make the same mistake twice.

The potential benefits of cognition enhancers are large, and growing as the population ages. It is clear that we should continue to devote resources to the development of cognition enhancers as treatments.

A more immediate question is how to respond to the increasing use of cognition enhancers by healthy individuals. While modafinil was developed to treat people with narcolepsy, it can allow healthy people to stay awake for up to 36 hours. It does not yet appear to have any negative side-effects and the long term effects are not certain. If the science community discovers how modafinil works, it could herald

a new category of cognition enhancement for the healthy. Modafinil itself has other potential uses. In addition to keeping people awake, it makes the user think through issues more carefully before making decisions. Decisions made under its influence tend to be less rash but take longer.

Methylphenidate (known as Ritalin) is another prescription drug that is being used off-label by healthy people as a cognition enhancer. It is being used by a small number of students in an attempt to improve exam results and by business people to improve their performance in the boardroom. Since its adoption at the fringe, following self-experimentation and word of mouth, scientific analysis has found that taking Ritalin can increase working memory. D-amphetamine also improves memory, but only for people with a certain genotype. There are other categories of drug that may improve memory.

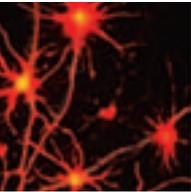
In a world that is increasingly non-stop and competitive, the individual's use of such substances may move from the fringe to the norm, with cognition enhancers used as coffee is today.

It is unlikely that we will be able to increase the performance of our brain in all ways at the same time. It is more probable that we will develop substances that allow us to optimise the performance of our brains for specific tasks at given times, whether that is paying attention to a complicated argument, enjoying time with friends or falling asleep at the end of a busy day. Just as in recent times there has been a pursuit of happiness, in the future the aim may be optimisation of the brain's performance. Individuals will still want to avoid addiction, so the aim may be optimisation with control.

It will be important to understand the long-term effects of such substances before their use becomes embedded in business and social culture. We would also need to develop a culture to support the sensible use of cognition enhancers and minimise the risks for example; it is not clear whether such substances will be addictive.

Issues for consideration?

Consideration of the long-term effects of off-prescription use of drugs, especially cognition enhancers, by the healthy.



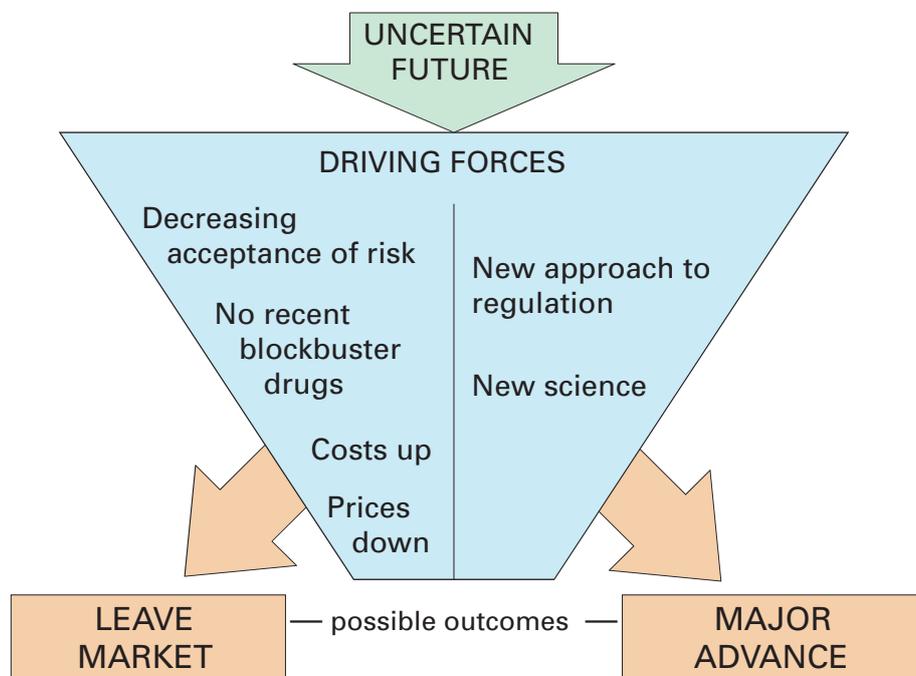
Future producers of psychoactive substances

Future producers of medicines for mental health

The project's science reviews show that there is the potential for significant advances in this area of research, and that new substances have many potential applications. However, the businesses that participated in our survey indicated that, although new discoveries might open new avenues for treatments, industry may not invest in the development of new medicines for mental health (see Figure 2). This is because they face:

- increasing pressure to reduce prices
- increasing costs of approval
- decreasing willingness to accept risk for new prescription drugs.

Figure 2: Competing pressures faced by business



Their hope is that innovations in science will help to meet these pressures. The first requirement is for a better understanding of the role of the different parts of the brain, including neurotransmitters, receptors, neurogenesis and the pathology of central nervous system (CNS) disorders. This may involve new animal models and, in the longer term, cellular culture models, to test the toxicity and effects of new drugs.

Also needed are increased predictive capabilities to help identify molecules with a good potential for treatment, and better targeting of medicines to specific individuals, on the basis of their genetic profile, to reduce the risks of side-effects.

Delivering these advances will require closer co-operation between academics and business. The UK Clinical Research Collaboration is expected to play a key role in ensuring that this link is made in the future.

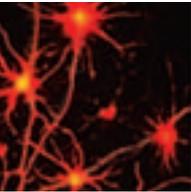
The arrival of some more successful drugs may encourage the industry, but five to ten more years without a blockbuster mental health compound could lead the pharmaceutical industry to focus its resources in other areas, such as the treatment of cardiovascular disease and cancer, where the chances of success are greater.

If demand remains high but the UK pharmaceutical industry is not able to stay in the market, companies in countries with less strict regulatory regimes may become the sources of supply. A growing number of drugs for mental health are available online from companies whose products are accepted for use in other countries but are not cleared for use in the UK. If self-medication and the online availability of such drugs increase, new approaches to the management of this issue may be needed.

Against this background, there is little incentive for the companies to develop treatments for addiction for illicit drugs. The size of the market is relatively small. There is also the potential stigma for a pharmaceutical company which devotes resources to an area that some perceive as a self-inflicted harm rather than an illness. Yet the costs of addiction are significant, an estimated £13 bn a year in the UK alone.

However, the pharmaceutical companies point out that their investment in medicines for mental health will probably lead to developments that will be available to treat addictions. An example is the development of drugs to manage stress, which is a key factor affecting relapse in drug users.

It may be in society's interests to fund innovative treatments for addiction rather than hope that it will arise serendipitously. If so, Government and industry will need to develop a new form of partnership.



There is a potential future market in the development of cognition enhancers for the healthy. It is not possible at the moment for the pharmaceutical industry to develop such drugs primarily for this purpose, because current regulations only allow the use of animals for the developments of treatments for ill people. There is also concern amongst the pharmaceutical companies about public reaction should they devote resources to the development of drugs for the healthy.

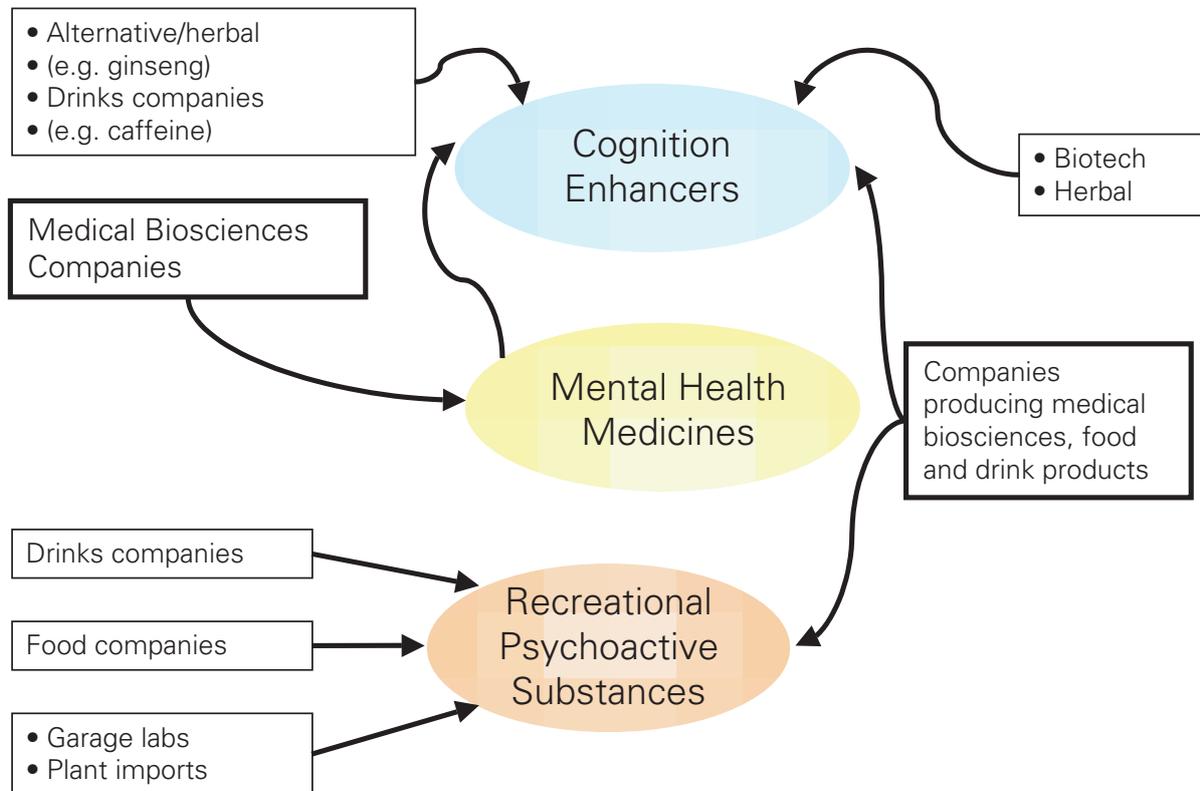
Issues for consideration?

The industrial/academic interface needs to be developed. For example, the industrial sector funds little work in the academic sector on improving methodology or paradigms for areas, such as standardising human tests of cognition in large normal populations or improving animal models.

Future producers of cognition enhancers for the healthy

If pharmaceutical companies continue to invest in cognition enhancers as medicines for mental health disorders, healthy individuals could continue to use them either as off-prescription drugs or, in the future, perhaps as over-the-counter products for healthy people. As society's perceptions of the use of such substances change, we may see some of the large food and drinks companies venturing into the production of substances that have been accepted by society, much as we see high-caffeine drinks produced today. This might lead to mergers or to new alliances in which food retailers provide the expertise in the mass marketing and the pharmaceutical industry supplies the science (see Figure 3).

Figure 3: Sources of current and possible future supply of psychoactive substances



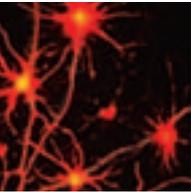
If in the future use of cognition enhancers by the healthy was accepted, we would need to consider whether we need to take steps to allow UK businesses to compete in this market. Current regulatory structures do not allow UK pharmaceutical companies to develop cognition enhancing drugs for healthy people.

Future producers of so-called 'recreational' drugs

Pharmaceutical companies may find that the drugs they develop for mental health are inappropriately used for 'recreational' purposes. This has happened with heroin, amphetamines and methylphenidate.

Illicit laboratories, which have supplied drugs such as cocaine, ecstasy and heroin for many years, are likely to play a role in the production of future 'recreational' substances.

Advances in technology such as the 'laboratory on a chip', and the growing availability of information online, may increase the capabilities of illicit producers and make it easier for them to develop novel 'recreational' drugs in smaller quantities. This may make it more difficult to discover where illicit drugs are being



manufactured. It might become possible to buy a 'lab on a chip' to produce one's own drugs, or to download online instructions for synthesizing them from common raw materials straight onto a chip.

Many big advances in therapy have come from unexpected sources. Perhaps the next major breakthrough in treatments for Parkinson's or Alzheimer's may come from some informal developer seeking to find the next rush. This has led to the suggestion that in the future we might have the 'open-source' development of drugs through collaboration of home creators and users of drugs, especially if pharmaceutical companies withdraw from the markets for the development of new medicines for mental health because they find the risks unacceptable.

Changing social perceptions of psychoactive substances

Medicines for mental health

There is evidence of growing use and acceptance of drugs for mental health. The youth of today is growing up with friends who use treatments for attentional problems, such as methylphenidate, or are using such a treatment themselves. The number of prescriptions for methylphenidate rose from 3,000 in 1991 to 120,000 in 1999. There has been a significant rise in the use of drugs such as fluoxetine hydrochloride (known as Prozac). This means that the current generation may be more prepared to take drugs than the previous one. If this leads to the destigmatisation of the use of medicines for mental health, this is to be welcomed. If it leads to a culture where medicines for mental health are relied on rather than seeking to develop a healthy society, it is not.

Medicalisation

Improvements in our understanding of the brain and behaviour have given us a better understanding of clinical conditions. For example, we can now recognise children with ADHD, there are treatments for disabling shyness (social anxiety disorder), and drugs are being developed to treat the cognitive decline that accompanies natural ageing.

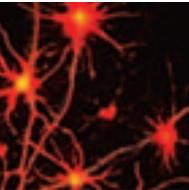
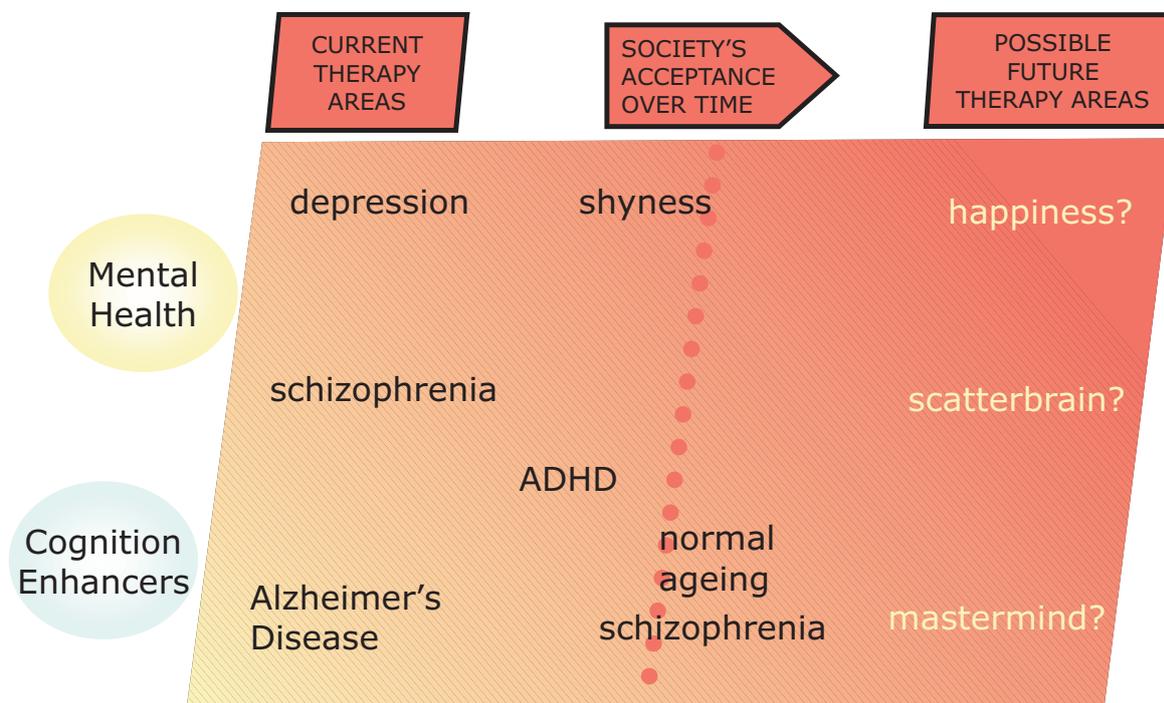


Figure 4: Possible future acceptance of medicines?



Normalisation

There is likely to be an increasing acceptance of use of drugs for an increasing range of conditions, with a blurring between those taken by someone who is unhealthy and those that are 'mental cosmetics' used to change our performance or mood to suit our situation or the social norm (see Figure 4). It is unclear, if we are going along this route, what the implications could be about the way society would perform. For example, dyslexics (who are good at seeing unexpected connections) and risk takers may be essential ingredients of a culture, needed to drive innovation and entrepreneurialism. It may be necessary to track future change and decide how to manage it.

So-called 'recreational' drugs

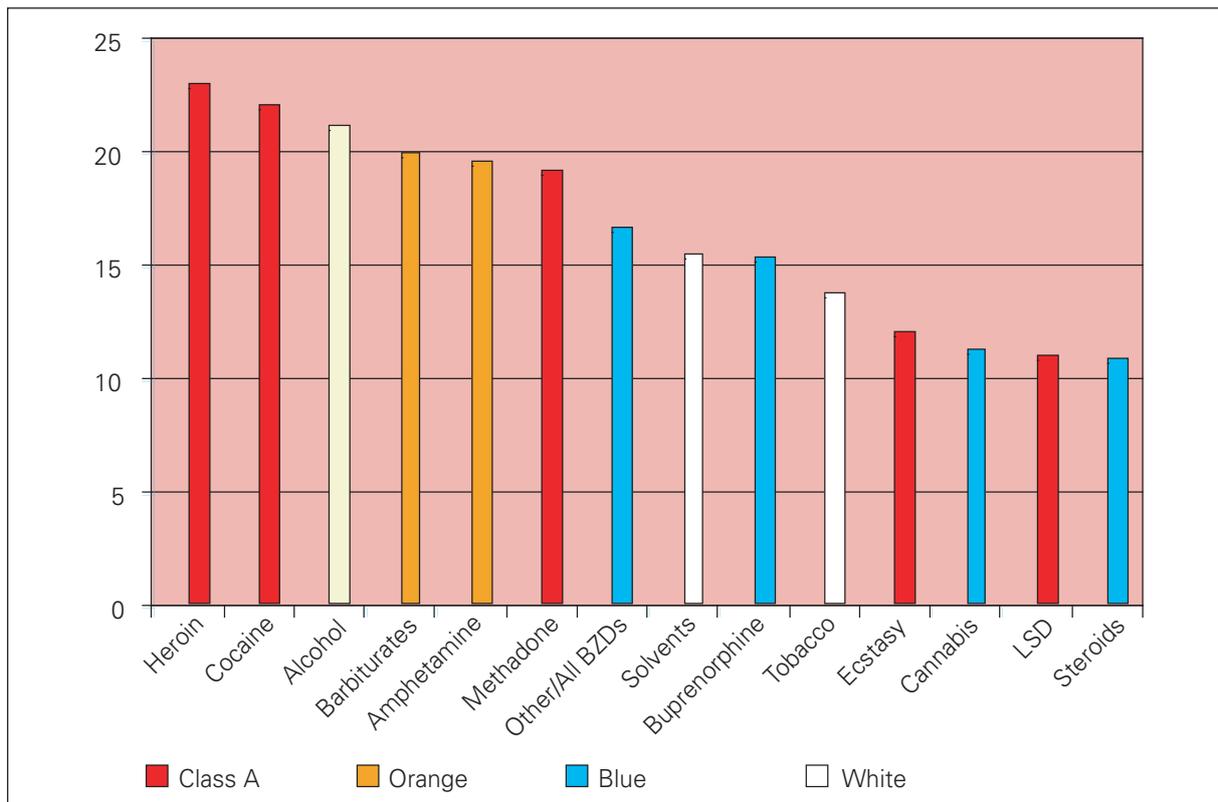
There appear to be three forces which are likely to drive changes in the balance of the acceptability of 'recreational' drugs in the UK:

- evidence of the harm that drugs cause to the user
- concern about the harm that users may do to others
- increasing pressure for the rights of the individual to enjoy 'recreational' psychoactive substances as they choose taking into account the potential of harms to others.

These forces act within the context of: the social role that certain 'recreational' drugs play in society; differing views about the acceptability of drug use; and the existing regulatory structure.

Recent studies have provided us with useful measures of the harms associated with the most commonly used 'recreational' drugs (See Figure 5).

Figure 5: Measurement of the harms associated with the most commonly used 'recreational' drugs (based on the Police Foundation study data from 27 independent psychiatrists with specialism in addiction)



Source: *Drugs and the Law: Report of the Independent Inquiry into the Misuse of Drugs Act 1971. Members of Inquiry: Viscountess Runciman (Chairman), A Chesney, R Fortson, J Hamilton PQPM, S Jenkins, A Maynard, L G Murray, DJ Nutt, D O'Connor QPM, G Pearson, I Wardle, B Williams, A Zera. Report published in 2000.*

The scale used:

Physical harm

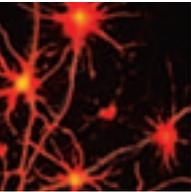
1. Acute harm
2. Chronic harm
3. Propensity for iv use

Dependence

4. Pleasurable potency
5. Physical dependence
6. Psychological dependence

Harm to family and community

7. Tendency for intoxication
8. Social harm
9. Secondary medical harm



It is striking that the two licit 'recreational' drugs assessed – tobacco and alcohol – are associated with severe harm.

Change in approach to management can be difficult if it leads to an increase in the control over the use of a substance and reduces the established freedom of individuals. But it appears that, as new evidence of harm becomes available, restrictions are accepted or demanded if the harm is to others. This has been seen in drink-driving legislation and in restrictions on freedom to smoke in certain public places. Individuals can still use these substances but their responsibility to others has driven a change in when and how they do so. If a 'recreational' substance harms only the user, its use is more likely to be managed by providing information on the risk and using taxes to increase the costs of use.

The battle between individuals' rights and responsibilities becomes more complicated when considering whether society should pay for the long-term health costs of an individual's decision to use 'recreational' psychoactive substances.

As pressures on health budgets increase, this could become a major driver in the debate about how we regulate drug use. We may see pressure for strengthening the control of today's permitted substances, perhaps with warnings on packaging for alcohol of the harm of inappropriate use and information on the number of units which drinkers are absorbing. The aim would be to help drinkers enjoy the benefits of alcohol but regulate their use in a more informed way.

Perceptions of risk

In our daily lives we all make decisions, but we cannot calculate the detailed balance between risks and benefits for every decision we make. Instead, we tend to use a rule of thumb based on our personal experience and the information available to us.

Thus, the views we hold about the use of drugs may not reflect their risks. For example, aspirin can be bought over the counter easily, but has as many health risks as Vioxx, which was recently withdrawn from prescription use. Vioxx is a powerful painkiller that served an important role. Following lobbying from users of the drug and further review, it was accepted that it could be used under conditions designed to minimise the potential risks to the user. This is an example of a tension between the desire for a solution through medicine and an increasing unwillingness to accept risks associated with their use. The debate on this continues.

It is very difficult to decide, even when there are clear benefits, whether it is acceptable for there to be risks associated with the use of a drug. This is a difficult issue for the regulator and for the manufacturer, which could face law suits and

significant commercial damage if even one in 10,000 of the users of a drug is harmed, while all the rest have benefited.

These pressures can be positive if they drive innovation and encourage the development of safe new treatments. Decisions about timing the approval of new medicines for mental health are difficult for the regulator, who faces patient pressure to release the new treatments as soon as clinical trials have demonstrated their effectiveness. However, it can be years before any long-term effects are known.

This issue is being managed with an increasing requirement that the company undertake post-release clinical trials. These additional safety checks increase costs and reduce the number of new products that reach the market, and there is increasing pressure to lower the risks yet further. This may lead pharmaceutical companies to withdraw from this market, as has already happened in the market for new antiseptics. The result could be unmet clinical need in an ageing population, or increasing self-medication with treatments from unregulated suppliers.

Issues for consideration?

We will need to consider how we can ensure that universities in the UK can continue to undertake small-scale 'proof of concept' studies in human psychopharmacology, which provide important objective evidence of drug effects.

These studies are now treated by a European Union Directive as being in the same category as large-scale, multicentre trials, typically funded by pharmaceutical companies. This results in long time delays and significant licensing costs. The expense is so high that universities now have to look to industry to cover these costs, with risks for the perceived independence of this work.

Finding the best solution for society may mean that we will need to learn to view risk in a new way. It may take many years, or a shock to the system, to bring such a change. We will need to decide whether to wait for the shock before we start the debate.

Recreational drugs also have risks (see Figure 6). If a drug has been with us for a long time and has become part of our culture, it is accepted for its benefits despite the harms that it might bring with it. Tobacco and alcohol are examples. There are four factors in addition to their familiarity within culture that have led to their acceptance. These are their perceived benefits, the lack of evidence for their harms, economic benefits, and social inertia.

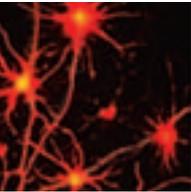
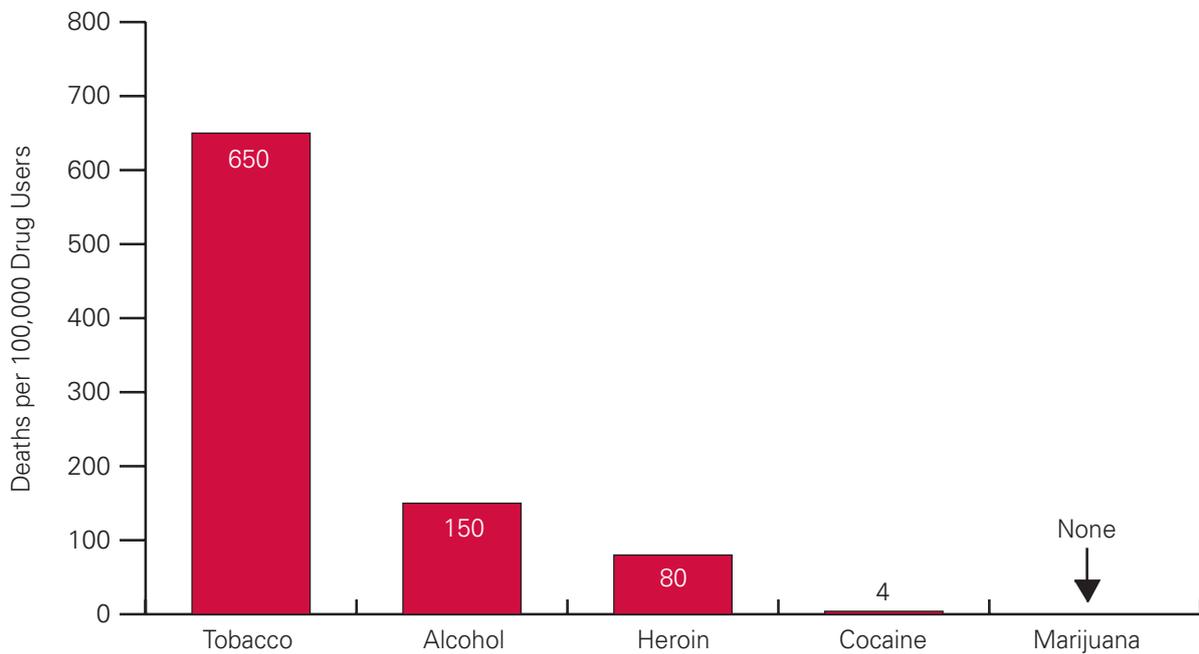


Figure 6: Deaths from Drug Use Per 100,000 Drug Users (by kind permission of the Beckley Foundation)



Source: Thinking About Drug Legalisation by James Ostrowski. Cato Institute Paper # 121

Increasing evidence on the harms of tobacco has changed perceptions of its acceptability. In particular, passive smoking has been targeted and there are fewer places where people are permitted to smoke.

Moderate consumption of alcohol brings health and social benefits. Hence its continuing acceptance in society. But increasing alcohol abuse through binge-drinking may change social perceptions of when and how we drink. An estimated 1.5 million people are addicted to alcohol in the UK and it is associated with 22,000 premature deaths a year. Nevertheless, it is available in many shops, although there are restrictions on when, where and to whom it can be sold.

The decisions we make on how we use drugs are complicated. They involve balancing perceived harms and benefits. But new evidence is likely to drive us to reassess our drug use in the future. For example, if we had an alternative to alcohol that had fewer harms (perhaps 2,000 rather than 20,000 deaths a year in the UK) but the same benefits, might it become accepted and embedded in society?

Widening the definition of addiction

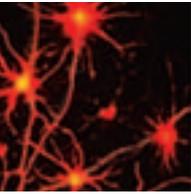
Our definition of addiction and how big a problem it is to be dependent on a substance has developed over time. The most recent extension of the term has been to behaviours such as excessive indulgence in shopping, gambling, eating, computer games and sex.

All agree that if addiction leads to harm it is a bad thing, but for many, addiction with little harm does not matter. An example is addiction to caffeine. But even this simple logic becomes more complex when the question is whether an individual should have the right to risk harm to him or herself or to others from the use of a psychoactive substance or behaviour. Increasing evidence on harms, and of future treatments for addiction, suggests that, over the next 20 years, debate may shift towards the potential harms that may come from drug use and away from problems with addiction *per se*.

Factors affecting vulnerability to addiction

It is not currently possible to assess an individual's vulnerability to addiction on the basis of their genes, nor is it likely to be in the future, given the probable involvement of a wide range of genes and the complicated interaction between genes and environment during the development of the brain and later in life. At best, genetic analysis may explain some vulnerability to drug use and addiction. It may also prove helpful in predicting vulnerability to the physical damage that drugs may produce. Other factors that affect vulnerability to addiction include age, social status and experience. For many substances, an individual is much more vulnerable to addiction during the brain's development in childhood or adolescence. This provides strong support for controls to reduce the likelihood of exposure of children and adolescents to addictive substances.

Low social status increases vulnerability to addiction. This is not something that can be remedied by psychoactive substances. Providing a culture and an environment in which people have a sense of self-worth and of their own value as individuals is an important route to reducing the risk of drug misuse. The challenge could be how to produce such a culture when our brain is stimulated so strongly by visual aesthetics if in the future we are immersed in media that suggest our value is determined by how we look and what we own.



Managing psychoactive substance use

The use of psychoactive substances is set to grow and bring significant benefits in healthcare. But the issues raised above, such as the off-label use of drugs, increasing ease of accessibility to 'recreational' drugs, different views on the acceptability of drug use, the simplicity of drug manufacture by criminal and informal groups, and the growing use of cognition enhancers suggest that the effective management of psychoactive substances will be an issue of increasing importance in the next 20 years.

Issues for consideration?

We need to build and maintain a UK network of scientists to develop new psychoactive substances for healthcare and produce evidence on the effects of new substances. It will be important to expand the interfaces between those already working in this field, notably between clinicians and biologists and social scientists and biologists. There are few researchers in addiction and related subjects in the UK. If we are to ensure that the science can meet long-term needs, the network needs to be nurtured and the interactions between the various areas of relevant science established more firmly.

Management of treatments for mental health

Key issues emerging here are:

- how to manage the continued increase in self-medication, including that of drugs not accepted by UK regulators
- how to manage the claims made for natural remedies and healthy food options. Medical and nutritional compounds are governed by separate regulatory regimes
- the implications of the trend towards normalisation of drug use on the long-term mental health of the nation.

We also need to consider why increasing numbers of people are being diagnosed as having mood disorders such as ADHD and depression. The approach to treating them might involve attacking the roots of these conditions rather than trying to cure the symptoms, whether with drugs or psychological treatments. Other social changes could increase the potential for drug abuse. The availability of information

and new forms of communication could allow new, currently rare, mood disorders to mushroom under future social pressures.

Collecting information on possible neurological problems is complex and must meet high ethical standards. This applies to sensitive studies such as research on the brain development of children and adolescents. It is also difficult to get approval to study the effects of illicit drugs. But if there is pressure for children to be treated for conditions such as ADHD and depression, there will need to be ways to evaluate the impacts, so that drugs that have only been tested on adults are not used to treat children and adolescents.

Issues for consideration?

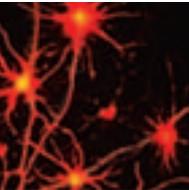
How to find the right balance between ethical considerations of research on children's brains and the importance of understanding the development of their brains so we can produce medicines for them.

To understand the interaction between social change and substance use will involve tracking influences on drug use, including treatments, over time. Data protection regulations make this difficult as it restricts researchers to using information for the specific purposes for which consent has been given. This raises another key ethical question for society. How can we ensure the protection and appropriate use of an individual's medical information and also ensure that we have the evidence to support the best decisions on psychoactive substance management for society? Pressure to protect information on individuals is very strong, surely we do not want to wait until we face a shock before some restrictions on the use of information on an individual's health are changed in order to allow more effective research for the common good.

It is also possible that some 'recreational' drugs which are currently illicit may be effective in the treatment of certain mental health conditions. Research on their efficacy might be worthwhile.

So-called 'recreational' drugs

The right approach to the management of 'recreational' substances will remain a sensitive and difficult issue. It is hard to collect evidence that would lead to a clear, easy and consistent decision on the management approach to different substances in society. Such decisions are a balance between the benefits and risks. These two are not directly comparable and society's perception of the weight of different factors on either side of the equation varies over time.



The choices we make will also be affected by the aims of our policies. Do we wish to reduce crime, or reduce harm to the health of individuals? Is the aim economic, whether to reduce the health and crime costs or to maximise tax revenue?

This does not mean that evidence is not valuable. Indeed, it plays an essential role in helping us weigh up the options against our values and make decisions that minimise harm.

The timing of any change to our management of psychoactive substances is crucial. An interventionist approach seeking to reduce use might be more effective if it is employed before a drug has become embedded in society. This underlines the need for effective mechanisms to watch for the arrival of new drugs and the social setting into which they fit. Such insights could play a key role in limiting the harms of any new 'recreational' substances. It might also become apparent that some psychoactive substances are less harmful. Their use might be encouraged to replace more harmful ones. This would require a change in the regulations because at present any new 'recreational' drugs with a risk of harm would be illicit, even if they carry only a fraction of the risk of current legal 'recreational' substances.

Once a 'recreational' drug has become accepted in society, there are only two broad ways in which an effective management approach for it can be introduced without such a risk of unexpected negative side-effects. The first is if the change is associated with a sudden shock. So, in the US, prohibition of alcohol was initially accepted in the aftermath of the First World War and lasted from 1919 to 1933. Smaller shocks could in the future provide similar opportunities. The other way in which change can be introduced is when it fits with the social mood, for example, the ban on smoking in public places in many parts of the world.

This means that effective change needs to be preceded by effective engagement with the public. This requires considerable investment and patience, but in the long run it can produce the best result. Such engagement has to work with society's acceptance of the best way to reduce the overall harm.

In the case of alcohol, the benefits it brings to many mean that it is unlikely to be banned in the next 20 years. But with growing concern over its abuse, society might embrace an increase in alcohol control. We might see regulation to encourage drinks manufacturers to market lower-alcohol products, and restrictions on the amounts individuals can consume in licensed premises. Such limits might be supported by future technology such as CCTV with behaviour-tracking software to identify people who are drunk and bar them from buying more alcohol

The effect that a drug has on an individual is partly learnt. It alters behaviour and mood in a way that depends on the social setting in which it is taken and the user's expectations. Culture also affects patterns of use. In some cultures, getting drunk is seen as the aim of drinking, whereas in others alcohol is used in smaller amounts

for its taste and as a social lubricant. In both types of use, it is seen as a means of bonding and as a communal experience. It is key that our policies seek to support the development of a culture that reduces harm. One approach is to improve knowledge of the risks of use.

Modelling

The complex interaction between culture, legislation and the way 'recreational' drugs are used means that it is unlikely that a single management approach will work for all substances. Even a single substance may need a range of management methods.

A group of scientists in Australia working on the effectiveness of different management approaches has grouped them into four broad categories³:

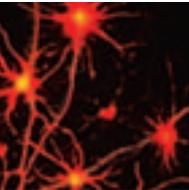
- crime reduction
- treatment
- harm reduction
- prevention.

There are around 30 types of management approaches under each of these headings. This, coupled with new evidence on harms, the dynamics of the cultural use of substances, changing social views of their acceptability and the varying approaches to management, makes decisions on the best approach to drug management complex.

To help manage this complexity, this project started to explore the possibility of using models to help us understand the consequences and effectiveness of changes to policy before they are introduced. Some organisations have already used models to assess the impact of providing needles to heroin injectors to reduce the risks of HIV. They show that unless a critical number of syringes are available, HIV will continue to spread as users share needles. Models can help to set targets for policy and inform decisions on the potential value of policy approaches such as needle exchanges. They can also ensure that all parties involved have a shared understanding of the issues and agree how to work together in response.

There is a broad range of approaches to modelling. Two types are statistical and agent-based. Statistical models are built on historical information and seek to produce a formula that shows how different factors have affected trends in use and harm. If a match can be found between the formula and historical trends, it is possible to get an idea of how policy changes might affect future use and harm.

3 Drug Policy Modelling Project. Turning Point Alcohol and Drug Centre, Australia.



Agent-based modelling, on the other hand, seeks to understand how individuals make decisions and the influences upon them, such as whether they are likely to meet someone offering a 'recreational' drug. Thousands of these agents interact in a virtual world to see what happens over time. The two methods can offer valuable but different information to help inform decisions on management approaches.

It is unlikely that we will produce a perfect model of the way society uses drugs, though over the next 20 years many useful models may be developed that will picture aspects of reality. Given the complexity of the issue it is likely we will need to use a wide range of modelling approaches. Crucial to the value of these models will be whether we have the data to build and run them.

To use these methods to best effect will require:

- a mechanism to collect and test new evidence
- modelling technology to inform decisions
- a dynamic regulatory structure that can be adjusted as clear new evidence emerges. We do not want, though, a system to be too sensitive, reacting to every research paper and newspaper article. It should support proportionate change on the basis of well-founded evidence
- a recognition of the cycle of drug use
- effective engagement with the public on the new evidence, allowing debate on the balance between the benefits and risks of psychoactive substances
- a recognition that changing approaches to management takes time and must be thought through strategically.

Issues for consideration?

We will need more information on the reasons people use 'recreational' drugs, the factors which affect their spread and the number of users, and the effectiveness of existing management approaches.

Management of cognition enhancers for the healthy

Cognition enhancers for the healthy do not fit easily into the regulations for food, medicines for mental health or drugs of abuse. The closest fit might be dietary supplements but substances that can enhance mental performance rather than just improve well-being could have far greater social impact. Given this potential significance, it is possible that there will be specific regulations dealing with the management of cognition enhancers for the healthy in the future. These regulations

would seek to minimise any risk of harms and would be likely to cover issues such as age and amount of use, use in education, the workplace and leisure.

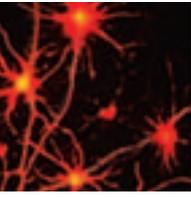
Drug testing

The development of new technology to make drug testing easier and cheaper is likely to have a significant impact on future management approaches if society wishes to go down this route. It would make it simpler to test for the use of drugs in the classroom and at work. The question in the future might be what we are testing for. Tests may be used to deter the use of 'recreational' drugs. But they might also be used to ensure that mood-altering drugs are being used but cognition-enhancing ones are not. Some US schools only allow children diagnosed with ADHD to attend if they have taken drugs for it.

The use of drugs tests could move to a new paradigm in the future, checking for cognitive performance rather than the presence of a particular chemical compound. The focus may move from whether someone has taken a substance to whether it has affected his or her capabilities. The tests now being built into cars that will only allow the car to be driven if the driver passes a test for alcohol may develop into tests for cognitive state. Roughly as many fatal road accidents are the result of people falling asleep at the wheel as happen because of drunk driving. This might mean that a user would have to take a wakefulness-promoting agent such as modafinil before their car would start.

International issues

An international approach is essential for drug management, not least because drugs are highly portable and tradeable. But the need for international agreement needs to be balanced against the need to make decisions at the local level on the tools needed to minimise the harm in each culture in which a drug is being used. In the same way, each country's approach will need to be decided partly in the context of its effects on other countries. International discussions on psychoactive substance management will involve listening to others, recognising the cultural context of each nation and building up an evidence base to help us to make better decisions.



Testing public opinion

We commissioned OPM to run a public consultation exercise to consider the public's views on some of the issues raised by the developments in science and society that had been identified by the project. This involved a series of workshops with six groups.

They were asked to consider three issues:

- individuals' rights to free choice versus society's rights to protect itself against harm resulting from the actions of individuals
- whether we might use drugs to prevent people taking other drugs that could lead to harm, or whether it is better to treat people only after they have used drugs
- whether the community could use drugs to treat behaviours that were on the edges of acceptability, contrasting this with the need to protect against a normalised society with a narrow range of accepted standards.

Individuals' rights versus society's rights

The group concluded that the former were more important. This was because they were not convinced that society would be able to choose what was right for everyone. They thought that it was better for individuals to choose and that the sum of those choices would be the best for society. An important presumption in this was that the current legislation on illicit drugs was right and that people should not be free to use those drugs except for medical purposes.

This highlights the challenge of making legislation more restrictive. The public did not want Government to make decisions that would reduce their freedom, but were happy with current restrictions that were imposed on them in relation to illicit drugs. It also suggests that there would be opposition to a relaxation of the legislation on illicit drugs.

Prevention with drugs versus treatment for drug users

The group was concerned about the possible use of preventative medicines to reduce the harms from 'recreational' drugs. Discussion focused on the possible use of vaccines to stop the action of specific 'recreational' substances. The public were

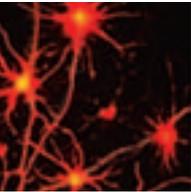
sceptical that genetics would provide reliable information on which to make good decisions. They thought there would be risks associated with preventative treatments and that they might restrict personal freedom by removing the option to use the substance in the future. It is even possible that drugs that we regard as 'recreational' might turn out to have beneficial properties. Current research is exploring whether nicotine might provide protection against Alzheimer's Disease. The group thought it would be better to use non-substance approaches to prevention, such as education, and reserve the use of medicines for the treatment of actual addicts.

Community safety versus risk of a society with normalised behaviours

They thought that we should not use psychoactive substances to treat behavioural conditions at the fringes of behavioural norms merely to deliver community safety. They were concerned about where such treatments would stop and feared that the population might be forced to use drugs to conform to social norms.

They also wanted:

- open dialogue on the use of cognition enhancers, information on vulnerability to addiction, decisions on the legal status of 'recreational' drugs and the possible use of vaccines to treat addiction
- adequate testing of new drugs. Thalidomide is still referred to as a touchstone of what happens when we get it wrong
- changes to the management of 'recreational' drugs to reflect evidence on harms not commercial pressures
- to stop measures which could reduce harm from illicit use of drugs, for example needle exchanges, if they sent a signal that it was allowable to take illicit drugs
- a careful approach to synthetic chemicals for cognition enhancement. The groups seemed more comfortable with products marketed as natural remedies
- approaches to managing mental health and drugs that go to the root of the problem rather than relying on quick-fix substance-based solutions.



Scenarios

The uncertainties about the future of brain science, addiction and drugs cover future scientific capabilities, the role of business and Government, and social attitudes. To help those in positions of responsibility understand how these various factors might interact, we produced four possible scenarios of the future. None of these is a prediction of the future, nor are any of them preferred futures. They are possible, sometimes extreme, futures designed to stimulate thought and to help spell out the opportunities and threats we might face and assist better-informed decisions today. The full details of the scenarios are available in a separate document and can be used to judge the risks and opportunities of policy relating to the future management of psychoactive substances.

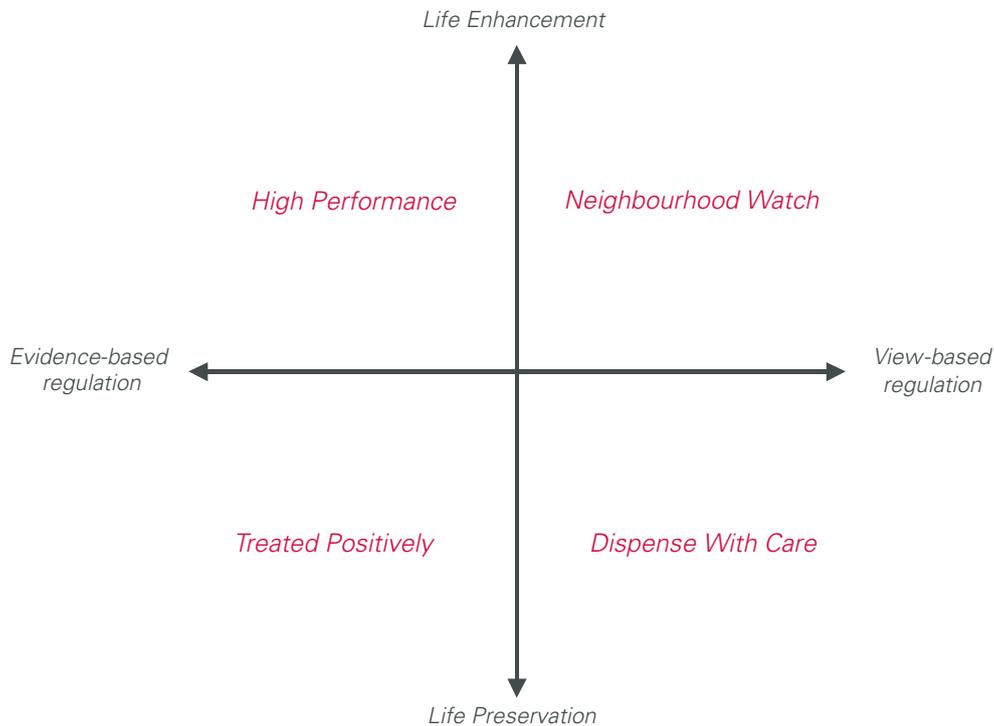
The four scenarios were set out along two axes of uncertainty.

Life enhancement \longleftrightarrow **Life preservation** describes the basis for psychoactive substance use. The axis relates to the views of the individual, community or society. At one extreme, life enhancement involves continuous modification of mood and behaviour. It may also include faster transition to medicalisation and more regulatory, market or cultural adaptation to non-medical uses. At the other extreme, life preservation includes all psychoactive substance use for therapeutic conditions. The axis provides a certain degree of flexibility about what is classed as a disease, which may change over time.

Evidence-based regulation \longleftrightarrow **View-based regulation** describes the basis for regulation. This axis relates to factors which underlie government regulation and control of drug use. Evidence-based regulation is informed by current scientific knowledge and is considered in light of the harms and benefits to the individual, community and society that are attached to the use of different psychoactive substances. View-based regulation describes an historical, moralistic and non-science-based policy approach to psychoactive substance control. It involves the control of psychoactive substances purely on the basis of their psychoactive properties, rather than taking into account their other effects, whether beneficial, harmful or pleasurable.

The axes combine to create a scenario space with four scenarios (see Figure 8):

Figure 8: Project scenarios

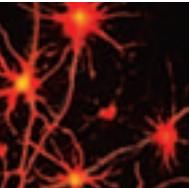


High Performance

High Performance is a competitive world where people work and play hard. Cognition enhancers have become highly popular and, following a period of unregulated use, are now used openly to enhance most types of work, under strictly controlled conditions that minimise harm. After some initial concerns, UK society is now ready to accept the use of some 'recreational' drugs, but only under equally strict and regulated conditions. People are able to identify their personal vulnerability profile and take responsibility for choosing substances likely to cause least harm. Addiction is seen solely as an illness to be treated, not a behaviour to be punished, and the number of problem drug users in society is falling. There is still, however, a level of hardcore supply and street use that needs to be tackled, both nationally and internationally.

Neighbourhood Watch

Neighbourhood Watch describes a world where policy decisions are made according to the prevailing social view and where the approach to drug policy changes regularly. Following a period of tolerance, particularly among the professional classes, drug use is now seen as a social ill that must be stamped out. Locally based community partnerships implement policy on drug testing in schools and the workplace. Their approach is punitive, with offenders subject to a 'one strike and you're out' policy. Research into the causes and mechanisms of addiction is not valued and there is little interest or investment in treatment. There are concerns



over the sustainability of this approach; some regions are relaxing the rules and the UK's strong focus on domestic policy has resulted in continued failure to tackle the international supply chain.

Dispense With Care

In *Dispense With Care*, the UK's ageing and demanding population places the NHS under severe strain. The number of conditions that can be treated has increased dramatically and the new generation of 'consumer patients' wants access to all treatments, irrespective of cost. But demand is not matched by a willingness to invest in the public sector and the NHS is forced to cut back on the number of drugs available to patients. This has led to an increase in private sector healthcare. In general, people are well educated about their health, and drug use has declined. Vaccinations against diseases such as Alzheimer's (and against certain forms of addiction) have increased but these are generally only available through the private sector. The NHS has been forced to exclude those requiring treatment due to self-harm.

Treated Positively

In *Treated Positively*, advances in our understanding of the molecular mechanisms of disease have transformed the nature of treatment and of the pharmaceutical industry. New, smaller, manufacturers use open-source technology to quickly create customised precision treatments that match individual disease profiles and the large pharmaceutical companies' dominance of the market is threatened. Greater understanding of genetic susceptibility to addiction means that individuals are able to select which psychoactive substances to avoid and even manipulate their own vulnerability profile. Cannabis is used therapeutically by the terminally and chronically ill and psychedelic drugs are being considered as therapeutic agents. Illicit drug manufacture – which has also benefited from advances in science – is cheap and sophisticated.

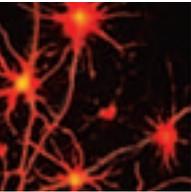
Comparison chart

Table 2 describes key differences between the scenarios according to:

- the basis of decision making by policy makers, individuals and society
- how psychoactive substances are used and viewed by society
- what is happening to manufacturers
- how society views addiction
- the ethical issues to be addressed.

Table 2: Comparison of the scenarios

	High Performance	Neighbourhood Watch	Dispense With Care	Treated Positively
Decision making	Based on scientific knowledge	Based on the prevailing social view	Based on the prevailing social view	Based on scientific knowledge
How psychoactive substances are used	Widespread, sophisticated use to optimise performance. Harm is minimised	Used according to personal cultural context and peer behaviour	General intolerance of psychoactive substances other than for treatment	Widespread acceptance for treatment, but use for recreation or performance enhancement is less readily accepted
Manufacturers	UK firms are strong suppliers; and move into manufacture and supply of cognition enhancers Generics are plentiful. The black market thrives	UK firms are strong suppliers Generics are plentiful Illicit manufacture moves along the international supply chain	UK firms have withdrawn from the development of new medicines for mental health China and India are key suppliers to private sector	Big companies under threat from open-source niche players Illicit production is cheap and sophisticated
Addiction	Not stigmatised Viewed as an illness to be treated	Not tolerated Punitive and criminalising regime	Not tolerated Addicts not criminalised, but excluded from support frameworks.	Not stigmatised Society is increasingly using preventative treatment for those at risk
Ethical issues	Whether to broaden controlled use	Whether the punitive approach is suitable and sustainable	How to deal with the legacy of the socially excluded	Whether to allow widespread interventions to prevent those at risk falling into harm



About Foresight

This project was one of a number of projects run as part of the Office of Science and Technology's Foresight programme. The aim of the programme is to produce challenging visions of the future in order to ensure effective strategies now. Four other projects have already launched their findings:

Cognitive Systems

Looked at developments in the physical and life sciences on thinking systems. The main objective of the project was to consider whether there would be value in bringing the two communities together to share their learnings. At the start of the project, they did not think there would be any value in such a collaboration, but by the end they thought there were three or four areas they would not be able to take forward without collaboration. The project led to a cross-research council initiative to take this forward. The project also explored emerging and future technologies, for a wide range of applications – transport, defence, leisure etc. The Economic and Social Research Council is now working with the Department of Health on the ethical, social and legal implications of the developments in relation to healthcare.

Flood and Coastal Defence

Explored the future potential risks of flooding up to 80 years in the future and the impacts of that flooding in five future scenarios to provide an idea of the range of possible future threats. A second set of scenarios was produced which then considered how we might respond to those risks and the costs of introducing responses that brought risks back to current-day levels. DEFRA is leading a cross-Whitehall action plan responding to the findings of the work.

Exploiting the Electromagnetic Spectrum

The UK developed the laser but makes little money from it. This project looked at future electromagnetic spectrum technology with a view to ensuring the UK captured the commercial benefits. It looked across the whole field and identified a number of key areas for investment – optical switches, medical and defence imaging and photonic manufacturing, and optical tools for 'lab on a chip' technology. It developed details of the technologies in each of these areas and roadmaps for the delivery of step-change capabilities.

Cyber Trust and Crime Prevention

Looked at developments in information and communications technology and trust. It considered future crime risks and what we might do to reduce those risks. In addition to a detailed report on future technologies, it produced a set of scenarios that have been used in gaming workshops by a number of government departments to test their policies for robustness in a range of possible cyber futures.

Current Foresight projects

Two other Foresight projects are running at the moment:

Detection and Identification of Infectious Disease

Is considering future technology that will help us spot new and emerging threats from human, animal and plant disease. The project has identified the key user needs and is developing detailed roadmaps that set out the science and technology we will need to deliver those capabilities. It is also mapping future potential risks and the events and decisions that could lead to future threats of disease.

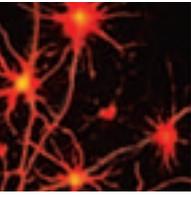
Intelligent Infrastructure

Is looking at the future of movement and how intelligence might be applied, whether in the design of where we live, or to provide us with real-time information and management of movement to deliver robust, sustainable and safe infrastructure for transport. It will produce a range of scenarios on how intelligence might be applied, depending on factors such as our future spatial planning policy, whether we have a low carbon power source for travel, whether we move towards more virtual rather than face-to-face meetings and whether society will be willing to cede control (e.g. self-driving cars) when they travel if it is the costs that they have to pay to travel quickly.

Office of Science and Technology Horizon Scanning Centre

The Office of Science and Technology also runs the Government's Horizon Scanning Centre. The Centre aims to provide a broad context of future opportunities, risks and developments across government with a particular focus on spotting the implications of emerging science and technology. It aims to explore novel and unexpected issues as well as persistent problems or trends. It offers support to government organisations with their own horizon scanning activities and is currently undertaking two scanning exercises; a broad strategic scan across the public policy remit and one providing a greater depth of analysis of emerging developments in science and technology.

Further information on this and the other Foresight projects can be found on the Foresight website: www.foresight.gov.uk



Acknowledgements

This project has been the result of the efforts and interactions of a wide range of people without whom the Office of Science and Technology would not have been able to tackle this broad and challenging task.

The Office of Science and Technology would like to acknowledge the following individuals for their contributions to the project:

Project key science experts: Professor David Nutt, Professor Trevor Robbins, Professor Gerry Stimson.

Project science writer: Martin Ince.

Stakeholder group: Jane Kennedy MP (Independent Chair), Lord Victor Adebowale, Professor Colin Blakemore, Assistant Commissioner Tarique Ghaffur, Eddie Gray, Vic Hogg, Professor Sir David King, Lord Richard Layard, Dr Sohaila Rastan, Professor Sir Michael Rawlins, Dr Gabriel Scally, Dr Sandy Thomas.

Advisory group: Rebecca Carpenter, Kevin Green, Professor Richard Green, Dr Jim Hagan, Kate Hall, Dr Declan Mulkeen, Dr Mark Prunty (Observer), Paul Richards, Rosalind Rouse.

Authors of the state-of-science reviews: Dr Richard Ashcroft, Dr David Ball, Professor Virginia Berridge, Professor Alastair Campbell, Dr Ben Capps, Dr Rudolph Cardinal, Dr Jonathan Cave, Professor David Cowan, Professor H Valerie Curran, Dr Patricia Di Ciano, Professor Colin Drummond, Professor Theodora Duka, Professor Barry Everitt, Dr Hugh Garavan, Professor Christine Godfrey, Dr Gordon Hay, Professor Peter Halligan, Kim Hellemans, Dr Tim Hickman, Professor Brian Hurwitz, Professor Les Iversen, Professor Roy Jones, Professor Terry Jones, Jonathan Lee, Dr Anne Lingford-Hughes, Charlie Lloyd, Professor Neil McKeganey, Dr Kelly Morris, Professor Peter Morris, Professor Joanne Neale, Professor David Nutt, Professor Jim Orford, Dr David Osselton, Professor Marcus Pembrey, Professor Trevor Robbins, Steven Robinson, Professor Robin Room, Professor John Rothwell, Professor Barbara Sahakian, Professor Dai Stephens, Caroline Tapping, Dr Danielle Turner, Dr Neil Vickers, Professor Steve Williams.

Peer-reviewers of the state-of-science reviews: Professor Nick Bosanquet, Professor Sir Kenneth Calman, Dr Luke Clark, Professor Ilana Crome, Dr Gerry Dawson, Dr Mark D'Esposito, Dr Harriet De Wit, Dr Rebecca Elliott, Dr Michael Farrell, Dr Jonathan Flint, Dr Sam Friedman, Dr Steven Glautier, Professor Wayne Hall, Dr Matthew Hickman, Dr Jeremy Holmes, Neil Hunt, Dr Stephen Husbands, Professor Susan Iversen, Dr Simon Killcross, Dr Leslie King, Professor Rob MacCoun, Dr John Marsden, Dr Marsha Morgan, Dr Michael Morgan, Dr Marcus Munafo, Professor David Nutt, Professor Anthony Phillips, Dr Robert Power, Rev Professor Michael Reiss, Professor Peter Reuter, Dr David Rubinsztein, Dr Eliot Stein, Professor Ian Stolerman, Professor John Strang, Dr Betsy Thom.

Ethical issues and addiction overview: Professor Wayne Hall.

The Horizon scan report: Professor David Nutt, Professor Trevor Robbins, Professor Gerry Stimson.

The Scenarios report: Andrew Curry, Rachel Kelnar, Alister Wilson.

The Perspective of the pharmaceutical industry report: Dr Ian Ragan.

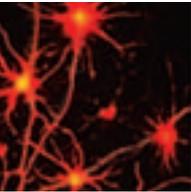
The Public perspective report: Dr Diane Beddoes, Dr Kai Rudat.

Authors of the modelling drug use report: Dr Edmund Chattoe, Dr Matthew Hickman, Dr Peter Vickerman.

Peer-reviewers of the modelling drug use report: Professor Jon Caulkins, Dr Katherine French, Professor Wayne Hall, Professor Rob MacCoun.

The Office of Science and Technology would also like to thank the large number of individuals from many organisations who contributed advice and assistance to this project.

Foresight team: Claire Craig, Samuel Danquah, Andrew Jackson, Jane Jackson, Mary Lawrence, Jo Marsden, Gerard Rand, James Withers.



Glossary

Abuse

The use of a drug in a way that causes harm.

Addiction

This term is contested. Addiction is generally regarded as a condition in which a person has a compulsive physiological or psychological need for a drug, or to perform a behaviour. This means that it is a more severe state than dependency.

Behavioural addiction

One of two principal types of addiction, to a behaviour rather than to a substance. Gambling is the best-known example.

Clinical psychology

The branch of psychology which emphasises treating mental disorder.

Cognition

The mental processes involved in knowing, including awareness, perception, reasoning and judgement.

Cognition enhancer

A drug intended to improve mental functioning, whether of the normal or impaired brain. Also called cognitive enhancer.

Cognitive neuroscience

The science of mental processes.

Dementia

A disease involving loss of cognitive function.

Dependency

A need for a substance which is sufficiently strong that an individual cannot function satisfactorily without it.

Drug

Chemical used to create an intentional biological effect.

Experimental psychology

The branch of psychology which treats the subject as a science in which the experimental method reveals information about the human brain and behaviour.

Gene

The basic unit of heredity, consisting of a portion of DNA at a specific point on a chromosome.

Genetics

The science of genes and their expression, in humans and other species.

Genome

The genetic composition of a particular species. The individuals which make up the species have distinctive polymorphisms (unless they are identical twins or members of a clone) that may affect their susceptibility to drugs.

Genomics

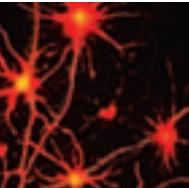
The study of the genes and their functioning within the genome of a species.

Harm

Ill-effect caused to a person or those around them by the abuse of a drug or other addictive behaviour.

Illegal

Not permitted by the law. This term is generally applied to drugs which are widely forbidden under national or international regimes, such as the Misuse of Drugs Act 1971 in the UK, which regulates drugs on a scale of severity. The legality of a drug may vary from time to time and from place to place.



Illicit

Illicit substances are those not permitted by law for general use.

Legal

Permitted by the law.

Licit

Licit substances are those such as tobacco or alcohol whose use is permitted by law subject to restrictions on their use (eg licensing hours for pubs) and their users (eg age limits on going into pubs).

Misuse

The illicit use of a drug.

Modelling

The process of generating a computer-based simulation of some process such as the changing use of a drug in society.

Neuroimaging

The use of scanning and other forms of technology to produce visual representations of brain processes in action.

Neurodegenerative disease

A condition such as Alzheimer's disease in which a pathology is associated with detectable change in the brain.

Neuroscience

The science of the brain or, strictly, of the nervous system.

Pharmacology

The science of drugs and their effects.

Problem Use

Drug use is regarded as problematic when it causes non-trivial problems to the user (including poor health or extreme financial or employment damage) or to others (such as damage to households or to wider society).

Psychoactive substance

A psychoactive substance is any substance or surrogate intervention that affects brain function through its chemical neurotransmitters. The term includes 'recreational', psychiatric, cognitive enhancing or mood altering drugs and also future technology such as trans-cranial magnetic stimulation or neural prosthetics.

'Recreational' drugs and so-called 'recreational' drugs

Is a drug which affects the brain and is taken for experience, or as part of the experience in a social context. This definition includes the legal 'recreational' drugs, e.g. alcohol and tobacco and the illegal drugs, e.g. cocaine and heroin.

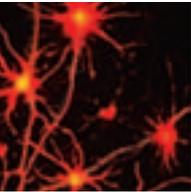
Substance addiction

One of two principal types of addiction, to a psychoactive substance rather than to a behaviour.

Testing

Testing is a term used in several ways in the context of drug use.

The main two are testing for drugs and their metabolites in the body, and the testing of new drugs. This occurs at a number of levels from tests on animals to large randomised trials in human populations.



List of publications: Drugs Futures 2025?

All publications are available in hard copy and/or can be downloaded from the Foresight website except those marked *** which are available only from the website (www.foresight.gov.uk).

1. Executive summary and project overview
2. State-of-science reviews ***
 - I. Cognition Enhancers
 - II. Drug Testing
 - III. Economics of Addiction and Drugs
 - IV. Ethical Aspects of Developments in Neuroscience and Addiction
 - V. Experimental Psychology and Research into Brain Science and Drugs
 - VI. Problem Gambling and other Behavioural Addictions
 - VII. Genomics
 - VIII. History and the Future of Psychoactive Substances
 - IX. Life Histories and Narratives of Addiction
 - X. Neuroimaging
 - XI. Neuroscience of Drugs and Addiction
 - XII. Sociology and Substance Use
 - XIII. Social Policy and Psychoactive Substances
 - XIV. Psychological Treatment of Substance Abuse and Dependence
 - XV. Pharmacology and Treatments
3. State-of-science reviews (2 page summaries)
4. Ethical issues and addiction overview ***
5. Horizon scan
6. The scenarios
7. Public perspective
8. Perspective of the pharmaceutical industry
9. Modelling drug use



Printed in UK on recycled paper with a minimum HMSO score of 75
First published July 2005. Department of Trade and Industry. www.dti.gov.uk/
© Crown Copyright. DTI/Pub 7917/3k/07/05/NP. URN 05/1182