Science & CRIME

Keeping one step ahead

Report of a seminar organised jointly by the Institute of Physics, the Royal Society of Chemistry, and the Institute of Biology

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Science and crime: keeping one step ahead

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Advances in science and technology - in areas such as IT, genetics, chemical analysis and imaging - are providing new methodologies for preventing crime and catching criminals in ways that weren't possible a decade ago. DNA testing and CCTV surveillance, combined with national databases and intelligent software, are just two examples of techniques increasingly used to identify suspected lawbreakers. Miniaturised analytical methods can detect minuscule amounts of drugs, toxins, explosives and other materials that might be used to commit a crime.

Such developments have undoubtedly contributed to the fall of 25 per cent in crime rates seen between 1997 and 2003 in England and Wales.* With these new and more refined techniques, however, comes a series of social issues relating to the forensic interpretation and understanding of complex scientific results, and to ethical concerns such as personal freedoms and anonymity.

To discuss the latest developments in crime science and the issues they raise, the Institute of Physics, the Royal Society of Chemistry and the Institute of Biology held a joint seminar in June 2004.

The seminar was chaired by **Professor Gloria Laycock**, Director of the Jill Dando Institute of Crime Science at University College London. Her particular interest is in applying new scientific ideas to preventing crime in a socially acceptable way. **Dr Allan Jamieson**, Director of the Forensic Institute in Edinburgh, discussed the interface between science and the law. **Alan Pratt**, Deputy Director and Chief Scientist of the Home Office Police Scientific Development Branch reviewed the workings of the Home Office in security and crime prevention, and discussed some of the new technologies being implemented. **Dr Keith Williams**, Head of the Forensic Toxicology Unit at LGC, described the types of testing used to identify drugs, such as those related to date rape. **Jim Fraser**, Head of Forensic investigation for Kent County Constabulary, discussed the new techniques used in DNA identification. Finally, **Professor Andrew von Hirsch**, Director of the Centre for Penal Theory and Penal Ethics at the University of Cambridge's Institute of Criminology, considered the ethical constraints in crime prevention, particularly in relation to CCTV surveillance.

New technologies

The past 15 years have seen enormous developments in technologies that can be applied to solving crimes and deterring criminal activity.

Alan Pratt described some of the strategies that the Home Office was developing to improve security and help the police carry out their jobs more efficiently. One strategy

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is to make environments more resistant to attack, for example, by understanding the physics of explosions and developing new materials that could resist them. A huge amount of work has gone into developing technologies to make portals such as airports more secure. For example, one promising area is that of terahertz imaging, whereby radiation with a wavelength range between micro and millimetre parts of the electromagnetic spectrum is used to image objects behind obscuring material.

Police need to feel well protected. Bullet-proof vests made of new tough, lightweight materials allows them to work unencumbered in difficult situations. The Home Office has also been evaluating weaponry that is less lethal than firearms. The taser, or stun gun, which disables a suspect with an electrical charge is a controversial weapon. "We have to make sure that anything that goes out on the street is fit for purpose - operational, effective and safe," said Mr Pratt.

Another important goal is to develop techniques that capture scene-of-crime evidence effectively and allow for rapid, correct evaluation. Fast imaging systems for capturing fingerprints using fluorescent materials have been developed and these are connected to a police national database for identification.

DNA testing

One of the most important developments in crime science has been the establishment of a national database for DNA samples. The England and Wales National DNA Database now holds 2.3 million DNA profiles from individuals, and 230,000 profiles from crime-scene stains. It is the biggest and most successful in the world. During November 2003, DNA from about 7000 people were matched to crime-scene stains, with 450 links between separate crime scenes established. PCR technology (which involves using an enzyme to replicate enough of a DNA sample to be analysed) has been automated using robotics so that analysis can now be performed quickly and reliably.

As well as identifying murderers, rapists and other criminals, automated DNA profiling has turned out to be effective in detecting less serious crimes. "I don't think that anyone anticipated the benefits in volume crime - the vast majority of subject matches in the database are related to car theft, burglaries and criminal damage," said Jim Fraser. "DNA profiling is a powerful tool in understanding crime patterns and developing tactics to reduce crime."

That approach may be enhanced by new DNA methodologies that are being developed. 'Familial' searching, based on identifying similarities in the DNA of related people, is now available to investigations where a full DNA profile has been obtained from a crime scene sample but no match has been found in the National DNA Database. It was first used in 2002 to identify, posthumously, the man who had raped and killed three girls in South Wales in 1973. Later, in 2003, familial searching was able to find a man who caused the death of a lorry driver by throwing a brick from a motorway bridge, by first locating a close relative.

The established method of DNA fingerprinting depends on analysing frequency patterns of repeating sections of DNA of different lengths, which vary from individual to individual. Today, even more complex methods of gene analysis are being developed using other patterns of DNA repeats. These patterns may be related to the sex of an individual (Y chromosomes in rape cases), or their ancestry - racial mix, or more contentiously, physical characteristics (the phenotype). Mitochondrial DNA which is inherited maternally can be used on very degraded samples of DNA. Another technology, rapidly gaining interest, is based on single nucleotide polymorphisms (SNP, pronounced 'snip') whereby single base changes in a DNA sequence can be mapped and variations compared in individuals. Again it's suitable for badly degraded samples. Since SNPs remain stable when inherited they have already been used to establish geographical origins and racial mix of a suspect. Research groups in the UK and in the US are already looking at methods for

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predicting hair and eye colour from DNA samples.

Eventually, said Mr Fraser, DNA databases will be combined on an international basis and will be integrated with sources of other forms of biometric data such as fingerprinting. Novel types of database searching are already being studied.

Chemical analysis

Another type of testing that has become extremely sophisticated is the analysis of forensic samples for small amounts of drugs and other chemical compounds. Today, it is possible to detect ultra-minute amounts of materials with analytical equipment relying on various forms of spectroscopy combined with advanced separation techniques, or molecular recognition relying on, for example, an immuno-response. Again many of the techniques have been automated.

Keith Williams explained that for tests to be forensically meaningful, it was essential to use them in the correct way. He described two classes of testing: presumptive and confirmatory. Presumptive testing is cheap, rapid and often portable, and gives the first indication of whether target substances might be present in a sample. The process can be heavily automated, often using an immunoresponse in combination with fluorescence for detection. It is not legally defensible, but is used to screen out negative results before going on to confirmatory testing, which definitively identifies and measures the amount of specific chemicals. Confirmatory testing is legally defensible but is usually time-consuming, requires expert operation, and is not portable - so is expensive.

Dr Williams emphasised that tests must be fit for purpose. One recent study to assess how much of a problem spiking drinks as a prelude to date-rape was, indicates the relationship between the two kinds of testing. Drinks in an Essex nightclub were randomly tested with a portable device based on an immunoassay. This produced positive results in 4 per cent of samples. However, a second, confirmatory test indicated that all the positives were in fact false.

Soon, however, it may be possible to carry out confirmatory testing in the field, rather than back in the lab. Microfabrication, combined with solid-state technology, is allowing chemical analysis to be miniaturised. A team at the Open University produced a miniature, automated analytical laboratory to go on board the Beagle 2 lander on the Mars Express mission. Similarly, portable DNA testing kits based on SNP technology are being developed using micro-capillary transfer on a silicon chip. “If these tools are going to come out of the laboratory, then we have to ensure that they perform to the correct standard,” said Dr Williams.

Evaluation

These advances raise many other issues - particularly in training the police to operate equipment that depends on complex physical, chemical and biological effects. Will they have the knowledge to evaluate results in a forensically meaningful way? The notion of false positives and even false negatives needs to be clearly understood.

The inappropriate or inadequate use of databases also creates problems, as was seen in the recent case of misidentification in South Africa of a British man as an American wanted by the FBI. In the case of DNA identification, the situation could be more complicated. For instance, searching a database consisting largely of samples from white males might not be helpful if the crime-scene sample comes from someone of different racial heritage.

According to Allan Jamieson, these issues become even more important when giving forensic testimony. “Scientific results are rarely impartial and we should recognise that it can be difficult to evaluate evidence in a way that’s not misleading,” he said. He gave the example of an exercise where the same fingerprint set was sent to a number of experts who came back with such a broad range of answers as to make the results meaningless.

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One of the problems is that scientific data obtained from a complex environment needs to be interpreted statistically, and in the context of other information. However, the courts demand a binary answer: guilty or not guilty, said Dr Jamieson. Juries are not trained to evaluate probabilities or the quality of the scientific methodology. Gloria Laycock pointed out that you needed to understand Bayesian statistics to interpret advanced DNA results.

Expert witnesses also need to understand the importance of presenting evidence to a jury in an intelligible way. There are psychological issues of presentation: a jury is more likely to accept an expert opinion if given confidently by a senior academic. Dr Jamieson believes that forensic scientists need to take more interest in the legal process, and that a multidisciplinary approach is necessary to set satisfactory standards in evaluating and communicating forensic evidence.

Social and ethical implications

Most experts agree that the ultimate goal of crime science is prevention. The use of biometric databases for identification and devices for surveillance in public places provides obvious routes. Random testing for drugs is another potential deterrent. These strategies raise significant ethical issues, however, as was highlighted by Andrew von Hirsch.

Professor von Hirsch discussed ethical constraints as they relate to CCTV surveillance. CCTV cameras are to be found on almost every street corner in major towns and there is little control on how they are used. "The country needs to develop some control over this method of surveillance," he said. Based on the conventions of anonymity and privacy we expect at home and at work, as well as in public spaces, he suggested that similar rules could be applied to the use of CCTV. CCTV film should be examined only when an incident has occurred and already been reported and that needs further investigation. Certain sensitive locations such as cashpoints might be examined more regularly. However, CCTV footage should never be used in public entertainment, or for private litigation purposes, he added.

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More research needed

The seminar revealed the importance of carrying out more research in all the issues concerning crime science. Physicists, chemists, biologists, sociologists and psychologists need to work together with lawyers, police and the Home Office to develop new methods of crime prevention and detection that produce accurate results - fit for purpose - within an acceptable ethical framework. The Engineering and Physical Sciences Research Council (EPSRC) has a programme called Think Crime, which encourages proposals covering the areas discussed in the seminar. The Home Office also encourages the academic community to feed through ideas that can be used to fight crime.

Further information

**The UK Home Office, Crime in England and Wales 2002/2003*, July 2003.

Websites:

EPSRC - Crime Prevention and Detection Technologies
www.epsrc.ac.uk/ResearchFunding/Programmes/Cross-EPSRCActivities/CrimePreventionAndDetectionTechnologies/default.htm
The Forensic Institute
www.theforensicinstitute.com
Forensic Science Service
www.forensic.gov.uk
Foresight - Cyber Trust and Crime Prevention Project
www.foresight.gov.uk/
Jill Dando Institute of Crime Science
www.jdi.ucl.ac.uk
Legal ethics
www.legalethics.com
LGC
www.lgc.co.uk
PSDB
www.homeoffice.gov.uk/crimpol/police/scidev/

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