

Impact case study (REF3)

Institution: University of East Anglia		
Unit of Assessment: 8 – Chemistry		
Title of case study: Intelligent Fingerprinting Ltd. – Drug screening using the sweat of a fingerprint		
Period when the underpinning research was undertaken: 2005 - 2016		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
David Russell	Professor of Chemistry	November 1991 – March 2016
Period when the claimed impact occurred: August 2013 to December 2020		
Is this case study continued from a case study submitted in 2014? Yes		
1. Summary of the impact		
<p>The spin-out company Intelligent Fingerprinting Ltd. was founded in 2007 based on the research of Professor David Russell. The company has now developed drug-screening cartridges and a fluorescence-based reader which together provide a non-invasive platform for the detection of drugs of abuse and their metabolites contained within the sweat of a fingerprint.</p> <p>In this assessment period Intelligent Fingerprinting Ltd. has received investment [REDACTED]. The company currently has [REDACTED] employees working in a bespoke manufacturing, research and office facility in Cambridge, UK.</p> <p>Since the launch of its first products in August 2017, Intelligent Fingerprinting Ltd. has developed an extended portfolio which is now sold [REDACTED]. The introduction of the fingerprint drug test provides a dignified and hygienic method of analysis with an improved user experience. The technology has had a direct impact across numerous sectors including drug rehabilitation services, workplace and occupational health services, the Coroners service, and within the criminal justice sector. Thus, Intelligent Fingerprinting Ltd. demonstrates economic and commercial impact together with direct impact on the health and well-being of individuals.</p>		
2. Underpinning research		
<p>Professor David Russell's research (UEA 1991 – 2016) was focused within bioanalytical chemistry, particularly in developing nanoscale-based approaches for novel chemical measurements. In 2005, gold nanoparticles were synthesised and then stabilised with a monolayer of Protein A. Anti-cotinine antibody was then bound to the Protein A on the nanoparticles to provide a conjugate that was used to detect the major metabolite of nicotine (cotinine) in the fingerprints of smokers. The antibody conjugates bound to the cotinine antigens, while a fluorescently-tagged secondary antibody fragment was used to image the fingerprints. Not only did the reagents detect the nicotine metabolite in fingerprints but they simultaneously provided a high resolution image of the fingerprint to establish the identity of an individual. This initial research was patented (1) and then published (2). Following publication, there was considerable media attention as this was the first report that a drug metabolite, and therefore drug usage, could be determined from the sweat deposited in a single fingerprint.</p> <p>These initial results provided preliminary data for a collaborative EPSRC research grant with Dr Sue Jickells and Dr Barbara Daniel from the Department of Forensic Science and Drug Monitoring at King's College London. The EPSRC research grant enabled the development of iron oxide based particles which were functionalised with Protein A/G. Protein A/G is a recombinant fusion protein that combines IgG binding domains of both Protein A and Protein G. This created an exceptionally versatile platform on which numerous classes of antibodies could be bound. The platform technology was used to conjugate various antibodies. The antibody-particle conjugates were used to detect: Δ^9-tetrahydrocannabinol (THC), the main psychoactive component of marijuana; methadone, a synthetic opioid generally prescribed as a substitute pharmacotherapy to heroin-dependent patients; 2-ethylidene-1,5-dimethyl 3,3-diphenyl-pyrrolidine (EDDP), the major metabolite of methadone; and benzoylecgonine, the major metabolite of cocaine (3) in the</p>		

fingerprints of volunteers attending a methadone maintenance programme. Publication of paper (3) prompted further significant media attention since the paper highlighted the detection of illegal drugs and drug metabolites from fingerprints using the antibody-magnetic particle conjugates.

An EPSRC Follow-on Fund grant was awarded to **Russell** in 2009 to further develop the antibody particle conjugates for forensic applications. Results from this study reported the multiplexed detection of *two* drug metabolites (from heroin and cocaine) in a single fingerprint (4). In order to simplify the assay format, a competitive enzyme immunoassay was devised. This immunoassay was able to determine the presence of cocaine in the sweat deposited in a single fingerprint showing, for the first time, that concentrations of cocaine present in a fingerprint were related to those found in oral fluid samples taken simultaneously from an individual (5).

3. References to the research

(UEA authors highlighted in **bold**; citation count from Google Scholar December 2020)

1. Patent: Fluorescence-based detection of substances
D. A. Russell, R. Leggett, E. E. Lee-Smith, S. M. Jickells and B. Daniel
Publication number: WO 2007/110605
2. "Intelligent" fingerprinting: Simultaneous identification of drug metabolites and individuals by using antibody-functionalized nanoparticles
R. Leggett, E. E. Lee-Smith, S. M. Jickells and **D. A. Russell**
Angewandte Chemie International Edition, **2007**, 46, 4100-4103. (citations = 235)
DOI: 10.1002/anie.200700217
This paper was highlighted by: Nature (2007, 447, 119); Nature Nanotechnology (2007, 2, 388); New Scientist, Chemistry World; Chemistry & Industry; C&E News; Analytical Chemistry; National newspapers - Sunday Telegraph; Daily Mirror; International media - CNN On-line; **Russell** interviewed by German and BBC radio.
3. Imaging of latent fingerprints through the detection of drugs and metabolites
P. Hazarika, S. M. Jickells, K. Wolff and **D. A. Russell**
Angewandte Chemie International Edition, **2008**, 47, 10167-10170 (plus inside cover). (citations = 138)
DOI: 10.1002/anie.200804348
This paper was highlighted by: Angewandte Chemie as a 'Very Important paper'; Nature Materials (2009, 8, 5); Discovery Channel on-line; Chemical and Engineering News (Dec 22, 2008, p34); **Russell** interviewed for BBC World Service Radio.
4. Multiplexed detection of metabolites of narcotic drugs from a single latent fingerprint
P. Hazarika, S. M. Jickells, K. Wolff and **D. A. Russell**
Analytical Chemistry, **2010**, 82, 9150-9154. (citations = 99)
DOI: 10.1021/ac1023205
5. A competitive enzyme immunoassay for the quantitative detection of cocaine from banknotes and latent fingerprints.
S. van der Heide, P. García Calavia, S. Hardwick, S. Hudson, K. Wolff and **D. A. Russell**.
Forensic Science International, **2015**, 250, 1-7. (citations = 29)
DOI: 10.1016/j.forsciint.2015.02.008

Grants Awarded:

Light it up: A nanotechnology approach for the acquisition of forensic evidence

D. A. Russell (UEA); S. Jickells and B. Daniel (King's College, London)

EPSRC, 2006-2009, GBP426,569 (UEA - GBP247,956)

Nanoconjugates for the detection of forensic residues

D. A. Russell

EPSRC Follow on Fund, 2009-2010, GBP100,047

4. Details of the impact

Intelligent Fingerprinting was founded in 2007. The company is a University of East Anglia spin out based on the research of David Russell. By the end of the previous REF period the company

had received GBP2,500,000 of investment, over three investment rounds, and had 11 employees working in office and laboratory premises within the Norwich Research Park Innovation Centre. At the end of 2013 the company was predominantly an R&D organisation developing its own products.

After considerable development by the company, the Intelligent Fingerprinting technology now has evolved into a single-use lateral flow screening device for the simultaneous detection of four classes of drugs of abuse analysed using a portable fluorescence reader. The user deposits a fingerprint from each of their 10 fingers onto the collection cartridge – taking a minute to collect the 10 fingerprint sample. A buffer solution is released and the full analysis of the four classes of drugs of abuse from the fingerprints is achieved by the reader within 10 minutes. Intelligent Fingerprinting is now a company that develops, manufactures and sells its unique products.

The majority of drugs of abuse testing is based on urine or saliva samples. Other matrices that are used are blood, hair and sweat. The sampling of these matrices is seen as invasive, unhygienic and can be intrusive and undignified if 'observed' samples need to be collected. The Intelligent Fingerprinting diagnostic screening test overcomes all of these limitations offering a unique product in the GBP3,900,000,000 annual global drugs of abuse testing market.

Investment and Employment

[REDACTED] [source A].

In October 2015, the company moved to a dedicated 11,000 square feet of manufacturing, research and office space in Cambridge, UK. [REDACTED]

[REDACTED] [source A].

The original patent was granted in Europe, Australia and the USA during the previous REF period. The patent was then granted in Canada and Japan in 2014. [REDACTED]

[REDACTED] [source A].

Providing Improved Alternatives to Current Drug Testing Methods

The Intelligent Fingerprinting product range was launched in August 2017. The first cartridge to be launched was for the detection of four classes of drugs of abuse (opiates, cocaine, amphetamine and cannabis). This original cartridge was subsequently modified, following customer requests, to detect methamphetamine rather than amphetamine. A second cartridge, focussed on the drug rehabilitation market, was launched in July 2019 that enabled the detection of opiates, methadone, buprenorphine and benzodiazepines. Both types of cartridges can be read using a dedicated fluorescence based reader. The first instrument was an original equipment manufacturer (OEM) reader. However, in January 2020 the company launched its own instrument. These combined products – cartridge plus reader - are a World first, offering a diagnostic result from a simple fingerprint sweat sample. This rapid (one minute for sample collection and 10 minutes for complete analysis of four drugs), non-invasive and dignified method of sample collection and processing has applications in multiple sectors. Importantly, with consideration of social distancing, and the desire to avoid the collection of biological samples, the Intelligent Fingerprinting drug screen is a hygienic method for drug screening analysis in the current Covid-19 pandemic.

The products are being marketed and sold within drug rehabilitation services, workplace and occupational health services, the Coroners service and within the criminal justice sector.

[REDACTED] [source A]. Examples from within each sector are provided below.

Drug Rehabilitation

The social care and health charity *Change, Grow Live* (CGL) works with UK councils across the country to support people whose drug use has brought them into contact with the judicial system. Working with police, prisons, courts and other health and social care services, CGL provides integrated drug and alcohol treatment interventions that aim to stop reoffending and further harm to individuals and society. The charity has rolled out the Intelligent Fingerprinting drug screening tests across 50 of its UK sites. The executive director of *Change Grow Live* has commented:

“Intelligent fingerprint testing is a new way we can carry out our standard drug testing. It makes testing a much easier and more pleasant experience for staff and services users, especially while we’re all following social distancing.

“When someone comes to us for support and is about to begin medically assisted treatment, we need to know what drugs people have taken. That way, we can make sure we’re prescribing appropriately and not putting service users at risk. Until now, we’ve been doing this with mouth swabs or urine tests, but intelligent fingerprinting is a lot simpler.

“With fingerprint testing, you just place your fingers on a plastic cartridge. The cartridge doesn’t record your fingerprint, it just collects a small sweat sample that can then be read in a machine in order to run the test. The testing takes around ten minutes, and people have told us it’s a much nicer experience than having to give a sample of saliva or urine.

“We saw a clear opportunity for using this technology to test people who are new to treatment, in response to social distancing and shielding..... People who need a test to get their medication can now come into the service, or be tested in the community, give their sample, have it tested, and be following social distancing the whole time. That makes it much safer for staff and for people being tested”

██████████ Executive Director of *Change Grow Live* [source B]

Workplace Testing and Occupational Health Services

A large number of companies are now using the Intelligent Fingerprinting drug screening system. Within the transport industry, *Abellio London Bus* is using the fingerprint drug test to screen 2,300 drivers and staff. Importantly this test was introduced following union consultation and approval, as a non-invasive and hygienic approach to drug screening [source C].

Precision Stevedores, a UK labour provider for ports and port businesses, is using the Intelligent Fingerprinting drug test for both pre-employment testing and monthly random tests for its workforce across the entire Humber and Trent port area.

“As a recruitment and workforce provider for the high-risk ports and shipping sector, it is paramount that we ensure the safety of our employees and their on-site colleagues. Therefore, we have adopted Intelligent Fingerprinting’s innovative technology as part of our active drug testing policy. The process can be carried out on-site and in-house by our HR staff, providing results in 10 minutes and an immediate insight into fitness for duty.”

██████████ *Precision Stevedores* Health and Safety Manager [source D]

In April 2020, *Precision Stevedores* sister company, *RMS Ports*, adopted the Intelligent Fingerprinting drug test to enforce company drug policy and Health & Safety obligations, enabling drug test samples to be taken from staff working in every major Humber port, from forklift drivers to management, with results available in-house within only ten minutes. [source E].

Many companies within the construction industry are now using the Intelligent Fingerprinting technology. For example, *Wilco Contractors Southwest Inc.* (Calgary, Canada) have adopted the fingerprint drug test as part of the recruitment process to assess fitness for work in the construction industry as part of its commitment to workplace health and safety. The company has calculated that using this fingerprint drug test will save CAD20,000 to CAD25,000 (01-2020) per annum as compared to urine testing [source F].

Coroners Service

The drug screening cartridge was initially trialled in collaboration with H.M. Coroner ██████████ in Sheffield. This trial showed for the first time that cocaine, opiates, cannabis and

amphetamines can all be detected in the sweat of a fingerprint collected from deceased individuals with >90% accuracy as compared to a full toxicological evaluation. The publication of this work lead to significant Worldwide media interest [source G].

The tests have been introduced into Coroners services across the UK, where the new technology is used to provide a simple, non-invasive drug test on the deceased immediately upon arrival at the mortuary. The results help to prioritise costly and time-consuming post-mortem investigations.

“Now that the system has been fully validated and tested for commercial use, we are delighted to add Intelligent Fingerprinting to our portfolio of tests.”

██████████ HM Senior Coroner for Staffordshire (South) [source H]

Criminal Justice Sector

Successful trials at Rome Fiumicino Airport (Italy) have shown that the Intelligent Fingerprinting drug screen, in combination with intelligence received, enables custom officials to detect body packing (drug mules) within 10 minutes. This contrasts to traditional approaches, which are costly to administer, require specially prepared testing facilities and take longer to screen potential drug smugglers. In one particularly significant case, a positive fingerprint drug screening test led to an abdominal X-ray which revealed over 100 drug filled packets hidden within the suspect's large intestine. [source I]

In summary, the Intelligent Fingerprinting technology has had significant impact in several arenas, viz.: economic and commercial impact with the establishment of a viable spin-out company; inward investment into the UK and revenue generation through bringing unique products to market which are now sold Worldwide; the introduction of the fingerprint drug test into a number of sectors has had a direct impact on the health and well-being of the individuals who are tested through use of this dignified and hygienic method of analysis with an improved user experience; and there has been impact on both public and professional services following adoption of the new technology.

5. Sources to corroborate the impact

- [A] Letter from Executive Chairman, Intelligent Fingerprinting Ltd. (dated 31st December 2020)
- [B] Change Grow Live, Executive Director blog (downloaded from CGL website May 2020)
- [C] Abellio London Bus – Customer case study (downloaded from Intelligent Fingerprinting website March 2020)
- [D] Precision Stevedores – Customer case study (downloaded from Intelligent Fingerprinting website March 2020)
- [E] RMS Ports – Customer case study (downloaded from Intelligent Fingerprinting website January 2021)
- [F] Wilco Contractors Southwest Inc., Calgary, Canada – Customer case study (downloaded from Intelligent Fingerprinting website March 2020)
- [G] Drug screening using the sweat of a fingerprint: Lateral flow detection of Δ^9 -tetrahydrocannabinol, cocaine, opiates and amphetamine.
M. Hudson, T. Stuchinskaya, S. Ramma, J. Patel, C. Sievers, S. Goetz, S. Hines, E. Menzies and **D. A. Russell**. *Journal of Analytical Toxicology*, **2019**, *43*, 88-95.

Paper highlighted in 177 press articles across 28 countries (Clippings service, October 2018, from page 9). **Russell** was also interviewed for BBC World service ‘Science in Action’ and BBC Radio 4 ‘Inside Science’ (aired in October and November 2018 respectively).
- [H] South Staffordshire coroner quote – Intelligent Fingerprinting press release 09/10/17 (downloaded March 2020)
- [I] Rome airport article from July 2019 – (downloaded from internationalairportreview.com, March 2020)