Institution: University of Stirling

Unit of Assessment: A4 Psychology, Psychiatry and Neuroscience

Title of case study: EvoFIT: Applying Psychology To The Identification Of Criminals

1. Summary of the impact:

Our research has made an outstanding contribution to the ability of police forces to apprehend criminal suspects, particularly in cases of serious violent crime. EvoFIT is a facial composite system (software and procedures), designed to help victims and witnesses of crime to create a likeness of the perpetrator's face. It was conceived by Professor Peter Hancock in the mid-1990s and has been developed into an effective system that is in use by police forces across the UK and abroad. Forces using EvoFIT have actively collaborated with assessment of the system, and evidence from field trials clearly demonstrates the impact: a world-leading 25-60% of composites made with EvoFIT directly lead to an arrest, four times better than the best previous system used by police forces. Our novel methods for interviewing witnesses and for presentation of composites have enhanced the success of EvoFIT, and are now incorporated in competitor composite systems used by other police forces.

2. Underpinning research:

The initial research for EvoFIT derived from Hancock's work at Stirling on the Principal Component Analysis (PCA) of natural images and on genetic algorithms. Computer analysis of faces was compared with human perceptions of the same face[1]. A model of human face perception, from PCA image analysis through to identification, won the BPS Cognitive Section 'Award For Best Paper' in 2000[2]. PCA analysis provided Hancock with a novel way to generate face images, while genetic algorithms provided a way to search for the best likeness. This fundamental research led to the conception of EvoFIT (as shown in Figure 1).

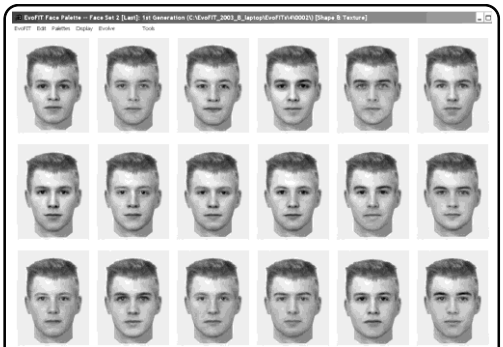

Figure 1. A screenshot of EvoFIT

A pilot system[3] led to funding from EPSRC in 1997, which supported a PhD student, Charlie Frowd. EvoFIT was further developed through a link grant (DTI/EPSRC) with ABM, a company selling security products, and then by another EPSRC grant (2005-7), which employed both Frowd and Alex McIntyre (Stirling RPG). Crucial to the success of the system is its development in Stirling's face laboratory, where the focus is on how humans perceive faces. Hancock and Frowd have applied this knowledge, along with basic principles of conducting research with human participants, to developing and evaluating the EvoFIT system. An early contribution was to establish a 'gold standard' method for evaluating composite systems, so that we were able to benchmark improvements to the system with confidence[4].

Having established the basic face processing technology and evaluation procedures we then considered all aspects of the process of producing a facial composite, from interviewing the witness to the best way to present the resultant image. Below we provide examples of how psychological theory has been used, one from each stage of the process.

1. Interviewing the witness: The established method is a 'Cognitive Interview', which includes a phase of context reinstatement, free recall and then prompted recall about each facial feature in turn. Witnesses are often unable to describe features well, and a key advantage of EvoFIT over traditional feature-based composite systems is that it does not require a detailed description. Another potential problem is a verbal overshadowing effect: having described a feature, witnesses may try to create something that matches the description rather than their memory. We developed a novel 'Holistic Cognitive Interview', where witnesses are asked to rate the remembered face for general characteristics such as intelligence, selfishness and aggressiveness. It turned out that a combination of feature description followed by the holistic ratings produced the most identifiable composites[5].

2. Focusing on internal face features: Studies of human face perception show that unfamiliar faces

tend to be remembered by external features such as hair, whereas familiar ones are recognised by the internal features. While witnesses are dealing with an unfamiliar face, the composite needs to be recognised by someone familiar with the perpetrator. We therefore hypothesised, and subsequently demonstrated, that blurring the external parts of the face during composite creation would force witnesses to concentrate on the inner features, resulting in more recognisable composites[6].

3. Animated caricature based composites: Studies of human memory suggest that performance is enhanced for distinctive stimuli, leading us to explore the possibility of caricaturing the composites. Caricaturing emphasises those parts of a face that are distinctive and there is evidence that caricatured line drawings of faces are more recognisable. Facial composites are typically poorly recognised and we tested whether caricaturing would improve this. The best format turned out to be a moving image, shifting slowly between caricature and anti-caricature. This technique is applicable to composites made by any system, not just EvoFIT, and indeed works especially well for relatively poorly recognised composites from traditional composite systems[7].

Until 2007, the work was carried out entirely at Stirling; Bruce, by then at Edinburgh, advised on the 'Evolving A Better Composite' grant. Frowd moved to a lecturing position at University of Central Lancashire in 2007; since then work has continued at both universities, with Frowd visiting Stirling regularly to discuss results and plan future work with Hancock and McIntyre, who remains in Stirling as a postdoctoral researcher.

3. References to the research:

1. **Hancock**, Burton & Bruce (1996) Face Processing: Human Perception And Principal Components Analysis. *Memory & Cognition,* 24, 26-40.
   [JCR IF 2011 = 1.922; Scopus Citation Count = 108; 5/66 for the journal that year]
2. Burton, Bruce & **Hancock** (1999) From Pixels To People: A Model Of Familiar Face Recognition. *Cognitive Science*, 23, 1-31. BPS Cognitive Section Best Paper Award.
   [JCR IF 2011 = 1.376; Scopus Citation Count = 143; 1/20 for the journal that year]
3. **Hancock** (2000) Evolving Faces From Principal Components. *Behavior Research Methods, Instruments and Computers*, 32, 327-333.
   [JCR IF 2011 = N/A; Scopus Citation Count = 30; 9/69 for the journal that year]
4. Frowd, Carson, Ness, Richardson, Morrison, McLanaghan & **Hancock** (2005) A Forensically Valid Comparison Of Facial Composite Systems. *Psychology, Crime & Law*, 11, 33-52.
   [JCR IF 2011 = .694; Scopus Citation Count = 44; 2/37 for the journal that year]
5. Frowd, Bruce, Smith & **Hancock** (2008) Improving The Quality Of Facial Composites Using A Holistic Cognitive Interview. *JEP: Applied*, 14, 276-287.
   [JCR IF 2011 = 1.754; Scopus Citation Count = 14; 16/34 for the journal that year]
6. Frowd, Pitchford, Bruce, Jackson, Hepton, Greenall, McIntyre, & **Hancock** (2011). The Psychology Of Face Construction: Giving Evolution A Helping Hand. *Applied Cognitive Psychology*, 25, 195-203.
   [JCR IF 2011 = 1.667; Scopus Citation Count = 10; 3/127 for the journal that year]
7. Frowd, Bruce, Ross, McIntyre & **Hancock** (2007) An Application Of Caricature: How To Improve The Recognition Of Facial Composites. *Visual Cognition*, 15, 954-984.
   [JCR IF 2011 = 2.049; Scopus Citation Count = 26; 4/60 for the journal that year]

Funding: All awarded competitively via full peer review.

Funding body - PIs	Year	Amount	Title/Rating
EPSRC – **Hancock**	1997-2000	£51K	An evolutionary face generator
EPSRC/DTI Link Bruce & **Hancock**	2000-2003	£172K	Crime-Vus (Rated: Outstanding)
EPSRC **Hancock**, Frowd & Bruce	2005-2007	£224K	Evolving a better composite (Rated: Tending to Outstanding)
EPSRC Public Engagement **Hancock** & Frowd	2006-2007	£36K	Sensational EvoFIT (Rated: Tending to Outstanding)

4. Details of the impact:

EvoFIT performance:

Irrespective of performance in laboratory studies, the real test for a facial composite system is whether the composites made are successfully identified, either by the police or members of the public. In the first case of a trial with Lancashire police, EvoFIT was used with an 11 year old girl who had been sexually assaulted in a park; this EvoFIT was identified by two members of the public and the attacker was sentenced to seven years in prison[A]. A photograph of the attacker is shown in Figure 2, alongside the EvoFIT composite that was used to catch him.

Figure 2. A sexual predator caught using EvoFIT

Following this initial success we engaged in a wider series of trials using a number of different police forces both in the UK and abroad. During a six-month trial of the system by Lancashire police in 2007-8, 30 composites were made, leading directly to six arrests, a success rate of 20%. Derbyshire police trialled the system for a year from mid-2008; they produced 57 composites, of which 19.3% led to arrests. Devon and Cornwall police started using an updated version of EvoFIT in 2010; during their first four months, 40% of the composites made led to arrests. In one case, a man reported himself to the police, since football teammates had identified the composite and threatened to contact police if he did not. A trial in Romania, using a specially constructed face-database, generated 24 composites, of which 37.5% led to arrests. These trials are fully documented and evidence regarding the benefits of EvoFIT is published[B].

A more recent field trial in Humberside police[C] resulted in 21 arrests from 35 composites (60%); this compares with 14% from the previous three years' use of the E-FIT composite system. An especially high profile case in South Manchester was solved using EvoFIT and our animated caricature technique. The same man attacked and raped two young women; the second of these made an EvoFIT that was shown in local media, including the Manchester Evening News (Figure 3). A number of people identified the man as a worker in a local fast food outlet; he confessed and has now been convicted[D].

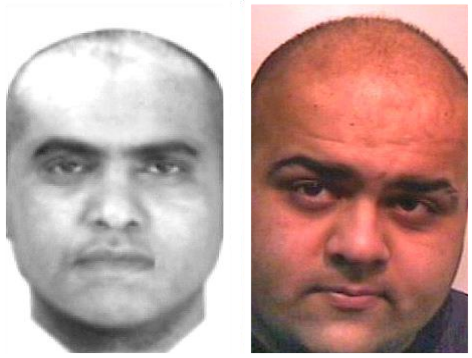

Figure 3. The South Manchester rapist caught using EvoFIT

The development of EvoFIT, and the associated interviewing and presentation techniques, continues. This development accounts for the steadily increasing success rate reported in the field trials. The latest research has demonstrated the utility of combining the various advances[E], and the science behind EvoFIT has also been described for a more general audience[F].

EvoFIT Reach:

Since 2008, EvoFIT has been used in 14 police forces across the UK, and throughout Romania, with over 3,000 composites made[G]; total income from sales and support is £106K. While EvoFIT is the primary outlet for our research[H], some of our techniques are applicable to other facial composite systems. Animated caricature has been adopted by both EFIT-V, another third generation system[I], and PRO-fit, an earlier feature-based system[J], and the holistic-cognitive interview works particularly well with PRO-fit and is routinely used with that system. Because our methods are embedded in rival software our impact extends to virtually every police force in the UK. In addition, our research places UK police ahead of other forces internationally – no other system in the world has been as thoroughly evaluated and demonstrated to work so well. Consequently, international police forces regularly enquire about using EvoFIT: it is being evaluated in Israel and Boston (USA). Geoff Whittaker of the Centre for Applied Science and Technology can speak to the wider impact of facial imaging in law enforcement[K].

Award nominations:

- Nominated for World Technology Award, 2004

- BBC Focus Magazine: one of the top British innovations of 2009
- Cited by the EPSRC as evidence of the impact of the research that it funds, winter 2009
- Shortlisted for a Praxis Unico Impact Award in 2010
- EvoFIT shortlisted for the Times Higher Research project of 2010
- Caricaturing shortlisted for the Times Higher Research project of 2011
- EvoFIT won the University Excellence Award at TechWorld in 2011

Public engagement:

Hancock and Frowd received EPSRC public engagement funding to build an EvoFIT installation at the Sensation Science Centre in Dundee, shown in Figure 4 at its opening. Visitors are able to interact with EvoFIT at a specially designed station, where they can try evolving a composite for themselves, while another station explains the science behind the exhibit. The centre attracts over 70,000 visitors per year, representing a significant impact on public understanding of the science of face identification. Public engagement funding from the BPS (awarded in 2012) is currently being used to support the development of new installations that are due to open in 2013 at the Glasgow and Bristol Science centres (350,000 and 185,000 visitors per year respectively). EvoFIT has been featured on television, including Crimewatch and 'The One Show'.

Figure 4. The opening of the EvoFIT exhibit at Dundee Science Centre

5. Sources to corroborate the impact:

A. An early case in Lancashire where EvoFIT was instrumental in solving the crime: www.tinyurl.com/qbkdlnm

B. Details of field trials with Derbyshire, Devon & Cornwall and Romanian police: Frowd, Hancock, Bruce, *et al.,* (2011). Catching More Offenders With EvoFIT Facial Composites: Lab Research And Police Field Trials. *Global J. of Human Social Sci.*, 11, 46-58. www.tinyurl.com/oopmljy

C. Details of recent EvoFIT field trials with Humberside police: Frowd, *et al.,* (2012). Catching Even More Offenders with EvoFIT Facial Composites. In Stoica, *et al.,* (Eds.) *IEEE Proceedings of 2012 Third Int. Conf. on Emerging Security Technologies*, DOI 10.1109/EST.2012.26 (pp. 20-26). www.tinyurl.com/op5mlu9

D. A Manchester case where an animated EvoFIT led directly to the arrest of a serial rapist: www.tinyurl.com/pzs3rcn

E. Details of the latest multi-technique lab trials of EvoFIT: Frowd, *et al.,* (2013). Whole-Face Procedures For Recovering Facial Images From Memory. *Sci. & Justice*, 53, 89-97. www.tinyurl.com/nres7w5

F. Article summarizing key developments: Frowd, Skelton, Atherton & Hancock (2012). Evolving An Identifiable Face Of A Criminal. *The Psychologist*, 25, 116-119. www.tinyurl.com/q9gvqhb

G. Police contacts to verify impact (contact details supplied with REF submission): Derbyshire Constabulary; East Yorkshire; Lancashire.

H. Commercial website for EvoFIT: Website also contains details of holistic-cognitive interview, animated composite, customer testimonials and details of media coverage: www.EvoFIT.co.uk

I. A 3rd generation commercial system (EFIT-V) incorporating our animated caricature: www.visionmetric.com (contact supplied)

J. PRO-fit 'feature' system, including our holistic-cognitive interview & animated caricature: www.tinyurl.com/pwhxuks

K. Contact to verify use of imaging technology in law enforcement: (contact supplied) CAST.