Overview
To conduct an empirical study of human expertise in anomaly detection and handling, comparing the knowledge and strategies used by experienced and inexperienced personnel working in forensic (e.g., fraud; human trafficking) and medical (e.g., nurse practitioner) domains to discover and resolve anomalies in small- and large-scale datasets indicative of undesirable activity; and to develop new theoretical understandings, embodied in a computational model, of how individuals integrate structural, semantic and statistical information sources to inform novel AI architectures for anomaly handling.

Thesis development
Anomalies are events in data that do not conform to expectations, which can serve as indicators of malicious activity. For example, sudden increases in server access may be a sign of a denial-of-service attack (large-scale data), while a failure by an otherwise reliable employee to finish a report on time may be a sign of a shift in behaviour commensurate with insider activity (small-scale data). Of course, these signs may not indicate malicious intent: increased server access may reflect a new marketing strategy, while failure to finish a report may reflect overwork or illness. The fundamental problem, then, is one of anomaly interpretation not anomaly detection. Extensive work exists on AI methods for anomaly detection, using techniques such as statistical profiling, rule-based and neural network approaches to data mining. Solving the problem of interpretation typically requires a degree of supervision of anomaly detection techniques from a human investigator, yet to date there have been no studies of how humans undertake the interpretation of machine-derived anomalies in complex datasets.

The focus of the successful candidates PhD will be facets of human behaviour that appear anomalous against a backdrop of routine activity. Behavioural data present some of the greatest challenges for anomaly handling:

a) Behavioural data are full of non-indicative anomalies (e.g., an ABI survey estimated that over 15% of insurance records contain errors, mismatches and voids);
b) One person’s anomaly is another's normality (e.g., a woman pushing a pram past a police station in Salford is normal – in Basra, it is a potential threat indicator);
c) Humans are already good anomaly detectors (e.g., voice stress analysis is redundant since telephone claims handlers can already detect anomalous voice changes);

3 Association of British Insurance: http://www.abi.org.uk/
d) Humans are poor interpreters of anomaly meaning (e.g., police officers often show a ‘lie bias’ interpreting evidence as indicating guilt, while lay persons show a truth bias). The goal of the proposed PhD is to conduct rigorous but realistic empirical studies of expertise in investigating and interpreting anomalies in behavioural data. The research programme will collect novel data sets that examine both *in vivo* (work-based) and *in vitro* (laboratory-based) performance of experienced and less experienced personnel undertaking anomaly search and comprehension tasks as part of their normal working practices. The data resulting from these studies will inform the development and testing of a psychologically-informed and computationally-specified model of strategic anomaly handling. In turn, the computational mechanisms underpinning the model will be made available as a novel class of heuristic algorithm for AI within defence and security applications.

**Working environment**
This interdisciplinary PhD will be centred in the Psychology Department under the supervision of Prof Tom Ormerod (http://www.psych.lancs.ac.uk/people/tom-ormerod), and be part of a large community of PhD students within the Department of Psychology at Lancaster and within the multidisciplinary Security-Lancaster. You will be able to benefit from a range of skills and expertise within these centres to develop an exciting and unique research project in this timely and topical area.

The DTC centre incorporates an area of expertise and excellence in Security and the Department of Psychology at Lancaster has an exceptional reputation in this regard. The Department has an outstanding track record of successful PhD submission within 4 years of registration – over 90% of students of recent students successfully submit on time.

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