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Forensic Science International 156 (2006) 171–181
Forensic Science International
www.elsevier.com/locate/forsciint

The contribution of forensic science to crime analysis and investigation: Forensic intelligence

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Received 24 May 2004; accepted 30 December 2004
Available online 15 August 2005

Abstract

The debate in forensic science concentrates on issues such as standardisation, accreditation and de-contextualisation, in a legal and economical context, in order to ensure the scientific objectivity and efficiency that must guide the process of collecting, analysing, interpreting and reporting forensic evidence. At the same time, it is recognised that forensic case data is still poorly integrated into the investigation and the crime analysis process, despite evidence of its great potential in various situations and studies. A change of attitude is needed in order to accept an extended role for forensic science that goes beyond the production of evidence for the court. To stimulate and guide this development, a long-term intensive modelling activity of the investigative and crime analysis process that crosses the boundaries of different disciplines has been initiated. A framework that fully integrates forensic case data shows through examples the capital accumulated that may be put to use systematically.

Keywords: Crime analysis; Crime investigation; Serial crime analysis; Data integration; Multi-agent perspective; Identification databases

1. Introduction

Since the 1990s, security and policing strategies have moved toward more intelligence-led and proactive frameworks. Their efficient use is often considered as a pivotal instrument for informing decision making at a strategic and tactical levels, for instance in order to fight terrorism or to appropriately deploy police resources. In particular, criminal intelligence is now broadly implemented within law enforcement organisations and through technologies such as databases, geographical information systems, data mining techniques, biometric security devices, and so on.

Beyond the recognised successes of identification databases such as DNA or AFIS, there is evidence that forensic case data could contribute more valuably to the provision of intelligence: it is recurrently discovered retrospectively, that all the information needed was previously in the files and could have been proactively used in order to solve the case earlier [1–4]. This weakness is generally widely recognised, but implementation of solutions to efficiently capitalise on intelligence that can be inferred from case data have shown to be very difficult to achieve, not to mention forensic science data, although it is demonstrated a posteriori, that this is one of the strongest type of evidential information due to its materiality [3].

In this paper, we argue that the forensic science community should participate much more actively in the intelligence debate and initiate an intensive modelling program in order to create a desirable synergy between forensic science,

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0379-0738/$ – see front matter
doi:10.1016/j.forsciint.2004.12.028

crime analysis, investigation and other fields related to the study of crime. From this long-term project, a better definition of intelligence processes that fully integrate forensic case data should result.

This program starts via a ‘‘bottom-up’’ approach that consists of collecting and classifying existing systems (DNA, AFIS, etc.) through the kind of intelligence they provide into an analytical framework that is abstract from the computer. The resulting structure is presented as an organised set of elementary logical steps whose relevance is evaluated in relation with the criminal context, the existing pragmatic constraints and other parameters imposed by the criminal justice system. Finally, the primitive inference structures identified are integrated into the specific process of serial crime analysis. This shows how forensic science can become part of an approach that facilitates the resolution of problems by sharing the knowledge of investigators, crime analysts and forensic scientists.

2. Forensic intelligence

The concept of forensic intelligence remains fuzzy, and consequently has led to difficulties in implementing methods in an operational environment. A clearer definition and conceptual advances show already important results, but this need to be further delineated. Forensic intelligence is still today often associated with the use of identification databases, such as DNA, AFIS, shoemarks, ballistic ‘‘fingerprints’’, etc. and much of the debate has focused on those systems and mechanisms to introduce technology for extending similar tools to other types of traces [5].

A definition of forensic intelligence based on computerised systems can be interpreted as defining a domain through its tools. This is undesirable. It is preferable to relate it with definitions coming from general theories of intelligence [3,6]. We favour one that is completely abstracted from the underpinning technology: *forensic intelligence is the accurate, timely and useful product of logically processing (analysis of) forensic case data (information) for investigation and/or intelligence purposes*.

This definition points to how the collection, collation, interpretation and dissemination of forensic case data can support investigation and broader intelligence programs. This non-traditional perspective potentially implies to revisit each step of the process, from what type of data has to be collected and how to organise them, to inferences drawn, organisations and communication channels to be designed.

As a starting point, it has been chosen to concentrate on the study of logical inferences in order to show the variety of situations where the interpretation of forensic case data can combine with reasoning processes drawn in the course of the investigation or in the generation of intelligence products. At this level, a general framework will better show the nature of the contribution that forensic science should provide to the intelligence processes and help to derive particular operational implementations in function of specific contexts and organisational structures.

It is assumed that from information to intelligence or in the course of an investigation, a reasoning process is carried out, which can be broken down into basic inference steps. These inferences can take a great variety of different forms, at different levels of detail, and require the use of a broad variety of specialised knowledge, a scientific attitude and potentially the integration of computerised tools [7]. In the first phase of this study, it is proposed to identify and classify elementary reasoning steps that are used, routinely or occasionally, already in an intelligence perspective [2]. These ‘‘building blocks’’ of our model will be called *primitive* (*forensic*) inferences.

3. Bottom-up approach: primitive forms of inferences

3.1. Primitive inference 1: the identity

This first elementary form aims at recognising a known person, even if he tries to hide his true identity. This inference was implemented as a structured and systematic process, at the end of the 19th century, through the Bertillonnage and its main component, the anthropometrical system. It can be expressed in the following way:

Compare the measurements taken from one person with a collection of measurements taken from previously condemned criminals, if a similar/close/analogue record is found, infer that both measurements come from the same person.

The same mechanism is obviously adaptable to use with other types of data, like fingerprints or DNA. It is also routinely used when characteristics of a suspicious object are compared with a collection of descriptions of stolen objects.

Of course, for each type of data the processing constraints can be very different, the analogy must be specifically treated (how to implement concepts such as ‘‘similar’’, ‘‘close’’ and ‘‘analogue’’), the global efficiency can vary, as well as the content of the reference collection. But beyond those specificities, the mechanism is the same and can be generalised as follows:

Compare the data taken from one person/object with a collection of data taken from a relevant reference collection of persons/objects. If a similar/close/analogue record is found, infer that both records come from the same person/object.

Of importance is the structure of the inference. It is not the topic here to define if the comparison process is computerised or how it is performed.

3.2. Primitive inference 2: the source

Historically, the use of fingerprints enriched the set of inferences by adding the possibility to connect traces with their source and conversely a source to traces associated with an investigation:

(a) Source to (previously unknown) trace

Compare a print taken from a person with a collection of traces collected from crime scenes. If a similar/close/analogue record is found, then infer that the print and the trace are from a common source.

This pattern can be generalised to integrate for instance DNA, ear prints, speech, CCTV images and also physical objects such as shoes and guns, it can be formulated in the following way:

Compare a print taken from a person/physical object with a collection of traces collected from crime scenes. If a similar/close/analogue record is found, then infer that the print and the trace are of common source.

(b) Trace to (previously unknown) source

Compare a trace collected from a crime scene with a collection of relevant reference prints taken from persons. If a similar/close/analogue record is found, then infer that the trace and the print are from a common source.

This pattern can again be generalised and expressed in the following way:

Compare a trace collected from a crime scene with a collection of relevant reference prints taken from persons or objects. If a similar/close/analogue record is found, then infer that the trace and the print are from a common source.

3.3. Primitive inference 3: the link

Often regarded as ‘‘side effects’’, that are not really anticipated [8], DNA databases provide a large quantities of links:

Compare a trace collected from a crime scene with a collection of previously collected traces. If a similar/close/analogue record is found, then infer that the traces are from a common source.

This formulation obviously applies to a wide variety of traces transferred from physical objects or persons and represents the basic inference in the detection of a linked series of crimes.

3.4. Primitive inference 4: the profile of the source

The objective here is to infer some useful characteristics of the source from an intelligence perspective, such as the colour of a car, the height of a person, the shape of a vehicle, etc.

From a trace, extract useful characteristic(s) (descriptor) of the source

It is not intended here to debate which characteristics are best to extract, or how they are to be extracted.

3.5. Primitive inference 5: the type of the source (classification)

In order to perform this inference, the required knowledge consists of a collection of possible classes of sources. The inference can then be seen as a classification process:

Compare a trace to a collection of descriptions of a reference collection of possible types of sources. Infer the type(s) of possible source(s).

It is not discussed here which (class) characteristic of the trace has to be extracted and compared. Usually, the type of source can be systematically inferred from collections of data (such as for guns, makes and models of cars, types of shoes and so on), however, it has been shown that it is difficult to maintain an up-to-date knowledge of these different types of physical objects.

3.6. Primitive inference 6: a list of possible sources

Often it is not possible to obtain unambiguous, highly definitive information from a trace. For example, the uses of putative, mixed, or partial DNA profile information means that the comparison of such a sample to a DNA database can result in not one single match, but a list of possible sources. This inference can be generalised as follows:

Compare a trace collected from a crime scene with a collection of relevant reference prints taken from a physical object/person. Infer a list of possible sources.

3.7. Primitive inference 7: a list of possible relatives

Similarly, some uses of DNA (particularly non-autosomai markers such as those of mtDNA and X- and Y-chromosomes) have the potential to infer a list of possible relatives to the source:

Compare a trace with a reference collection of prints taken from persons. Infer a list of possible relatives.

3.8. Synthesis

Primitive inferences 1–7 (Sections 3.1–3.7) form a basic framework for forensic intelligence, mainly based on analogical reasoning, which collates a great part of existing approaches and databases.

This inventory does not pretend to be complete, as various items of information, such as those from forensic computing and intelligence provided by the analysis of mobile phone, have not been mentioned. It does not include consideration on inferences related to crime reconstruction and how this process should be modelled [9]. These could include a sequence of shoemarks, the trajectory of a bullet, the relative positions of other evidence at the scene, etc. It needs thus to be expanded. A wide range of the activities of forensic science laboratories can already be thought of as part of this framework, but unfortunately each trace is generally considered separately, and knowledge of the criminal context is seen as undesirable as it can potentially endanger the objectivity of the scientific process by introducing a so called ‘‘context effect’’ [10]. This relatively autonomous component is generally seen as weakly coupled with other parts of the criminal justice system, as it seems to necessitate few, or even to avoid entirely interactions with other partners.

This misleading model is still often conveyed by major forensic scientists and their organisations that consider themselves as only provider of evidence for the court, largely disconnected from other parts of the criminal justice system. There is evidence that this attitude causes a net loss of information and ambivalence in the role played by each participant in the overall resolution of problems [1].

4. Resolving the ambivalence

The confusion can be illustrated by a number of examples integrating the proposed primitive inferences.

4.1. Tactical assessment

A series of more than 20 burglaries was detected through shoemarks and modus operandi comparisons. Information about possible suspects was available, but another important case monopolised all the investigative resources. An armed hold-up with violence then occurred in a restaurant and a very poor quality shoemark was collected. The comparison process of the fragmentary mark with other shoemarks on file provided a possible link with the previously described series of burglaries. This tenuous link was explained to investigators by the forensic intelligence team and provoked a change of priority in the investigation. The series was then rapidly solved, but the shoemark evidence was never presented to court. Its quality was valuable to lead the investigation but insufficient as a sole evidence of identity. The exclusively intelligence-based role of the trace was very well understood by investigators and crime analysts.

In a more traditional framework, this decisive piece of intelligence would have been lost, resulting in poor prioritisation. Appropriate communication channels have provided timely expertise to combine the use of modus operandi, knowledge about current investigations and forensic case data in a management perspective. Those necessary exchanges between investigators, managers and crime analysts, who cooperate in the global resolution of a problem, show that forensic intelligence can hardly be studied in isolation. The study of the nature of those relations starts by considering structural and pragmatic constraints pertaining to the overall context, the nature of the data treated and the context designed by the crimes themselves. A better understanding of the influence of this context will help to further characterise forensic intelligence and mechanisms to efficiently implement it.

5. Primitive forensic intelligence inferences within their context

Critical factors can be illustrated by a set of situations:

1. Intelligence must be *timely*. For instance, Primitive inference 2(a) (Section 3.2) (source to the trace) is generally carried out under time pressure as it is frequently applied to check an arrested suspect against a collection of traces. The suspect is thus likely to be released before the end of the analysis. The same is true for Primitive inference 1 (Section 3.1) (identification of a recidivist) since the identification of a person can only wait on the laboratory for a finite period of time, unless, due to the criminal case under investigation, a suspect can be kept a sufficient time in custody.
2. Legal constraints tend to separate forensic case data into different sets. The cross comparison of all available information is simply impossible and can introduce linkage blindness, i.e. the inability to detect relevant connections between entities whereas they exist [11–14].
3. Economic and legal constraints can limit the number and nature of forensic case samples that are collected and analysed. For instance, legislative criteria or insufficient funding can restrict the analysis of biological evidence and the inclusion of additional DNA profiles onto a database. This can also introduce linkage blindness.
4. Complexity or imperfect information underlie other limits that preclude the cross-comparison of all available data. It is particularly evident when evaluating the possibility to build computerised comparison systems for certain evidence types such as toolmarks, earmarks or CCTV images.
5. The ability to efficiently implement Primitive inference 2(b) (Section 3.2) (trace to the source) through databases for shoes [15] and guns [16] is complex mainly because of the legal difficulties and pragmatic constraints pertaining to the recording of an adequate and relevant reference collection. Overly restrictive legal rules for the recording of DNA profiles can also be an obstacle in the application of the same primitive inferences. It has been shown that violent offenders were often already known to the police for having perpetrated less serious crimes [17] but were unable to be DNA tested due to the composition of the governing legislation.

Those examples show that the appropriate application of primitive inferences must be carefully and circumstantially evaluated within a broader intelligence-led system. Moreover, at a more specific level, forensic intelligence appears in a great variety of forms, but brings only parts of solutions that must be integrated and interpreted with other pieces of intelligence. Its relationships with crime analysis and investigation will be further scrutinised, from a logical perspective, to determine how inferences can be integrated into more general analysis processes. This approach is critical to clarify the implementation of communication channels that would favour the global completion of intelligence processes through the exploitation of forensic case data.

6. Combining expertises in inferences processes

The involvement of a great variety of knowledge is necessary to make the whole logical processing efficient as it encourages cross-fertilisation with different domains surrounding forensic science. The appropriate use of this knowledge in the treatment of data is actually what is called 'analysis'. This separation in domains of expertise is undesirable as the provision of intelligence results from one single process. Linkage blindness often results from such distribution of territories. However, all the necessary knowledge can obviously not be detained by a unique agent. In actual implementations, tasks largely overlap leading to a confusion of roles. It partially comes from the fuzzy understanding of forensic intelligence and poor awareness about its possible contribution. Solutions also often result from intensive discussions between practitioners that cannot straightforwardly be rationalised in terms of the participation of each contributor and the way they communicate. In order to better understand the nature of this process, it has been proposed to model this mechanism from a multi-agent perspective [18,19]. An ''agent'' is an abstract entity that contributes to the global resolution of problems. It will be arbitrarily assumed that there are three agents involved in the resolution of the problems: an investigator, an analyst and a forensic analyst. It is obviously an oversimplification of real processes, but can be used as a useful paradigm to study problems independently of a specific implementation and can be related to concrete attempts such as the creation of specialist advisor in major crimes (UK) and various forensic intelligence units within organisations.

Example 1. Bomb devices linking (analyst–forensic intelligence analyst)
Johnston [20] describes an intelligence effort that has been made in order to derive tactical strategies in the fight against al-Qaeda activities. The logical process is decomposed in Fig. 1.

This example illustrates the contribution of each participant toward the production of recommendations. After step 1 (Primitive inference 3, linking) (Section 3.3) and 2 (specific knowledge on bomb manufacturing processes), forensic intelligence is integrated into broader analysis of the mechanism pertaining to the terrorist enterprise that finally leads to a tactical recommendation. The process is rather linear and clearly separates the contribution of each agent. It can be readily implemented with well-defined specialised structures and formalised communication channels.

Example 2. DNA screening (crime investigation–forensic intelligence analyst)
DNA screening is becoming a standard approach of crime investigation and has been successfully applied in a variety of situations. Primitive inference 2(b) (Section 3.2) (trace to the source) is definitely the mechanism, but the definition of the reference collection arises from previous advances in the criminal investigation and results of other analysis in order to best determine a restricted and promising circle of ''suspects''. The Fig. 2 depicts the inferential process. Putative, mixed, or partial DNA profiles are also considered, resulting in the application of primitive inferences 2, 6 or 7. After this step, the investigator again takes the lead to pursue his/her investigation that should lead to the localisation and arrest of a suspect.

Again, the process shows a linear structure that separates clearly each agent's contribution. At least, the investigator and forensic analyst would agree that the intelligence provided has the status of a ''lead'' and not of evaluated evidence usable for court purpose. In the course of crime investigation, investigators obviously can use other forms of intelligence provided by the interpretation of forensic case data. This can result in more complex exchanges of information as are illustrated in the following example.

Example 3. Geographical/temporal analysis of shoemarks
An original analysis form based on the geographical/temporal consideration of types of shoemarks, glovemarks and toolmarks has been applied in the investigation of serial burglaries [3,15]. This approach demonstrates the potential for the systematic application of a two-step method:

1. provide a promising set of cases from extraordinary concentration of burglaries based on common general characteristics of recovered shoemarks, glovemarks or toolmarks;
2. further scrutinise this set of data by combining with other types of data to find links or allow assumptions as to the existence of a crime series.

An example of patterns that can be detected, is described in Fig. 3.

The exact contribution of each agent to this method is far less clear than in the previous examples. If step 1 reasonably belongs to the forensic analyst, step 2 can involve other agents in an intensive non-linear communication process that takes into consideration geographical, temporal and modus operandi aspects, current investigations and crime analysis. In a lot of domains, such as for the analysis of illicit drug seizures, the use of forensic intelligence is promising, but a lack of available collective experience still precludes the design of precise guidelines for its implementation.

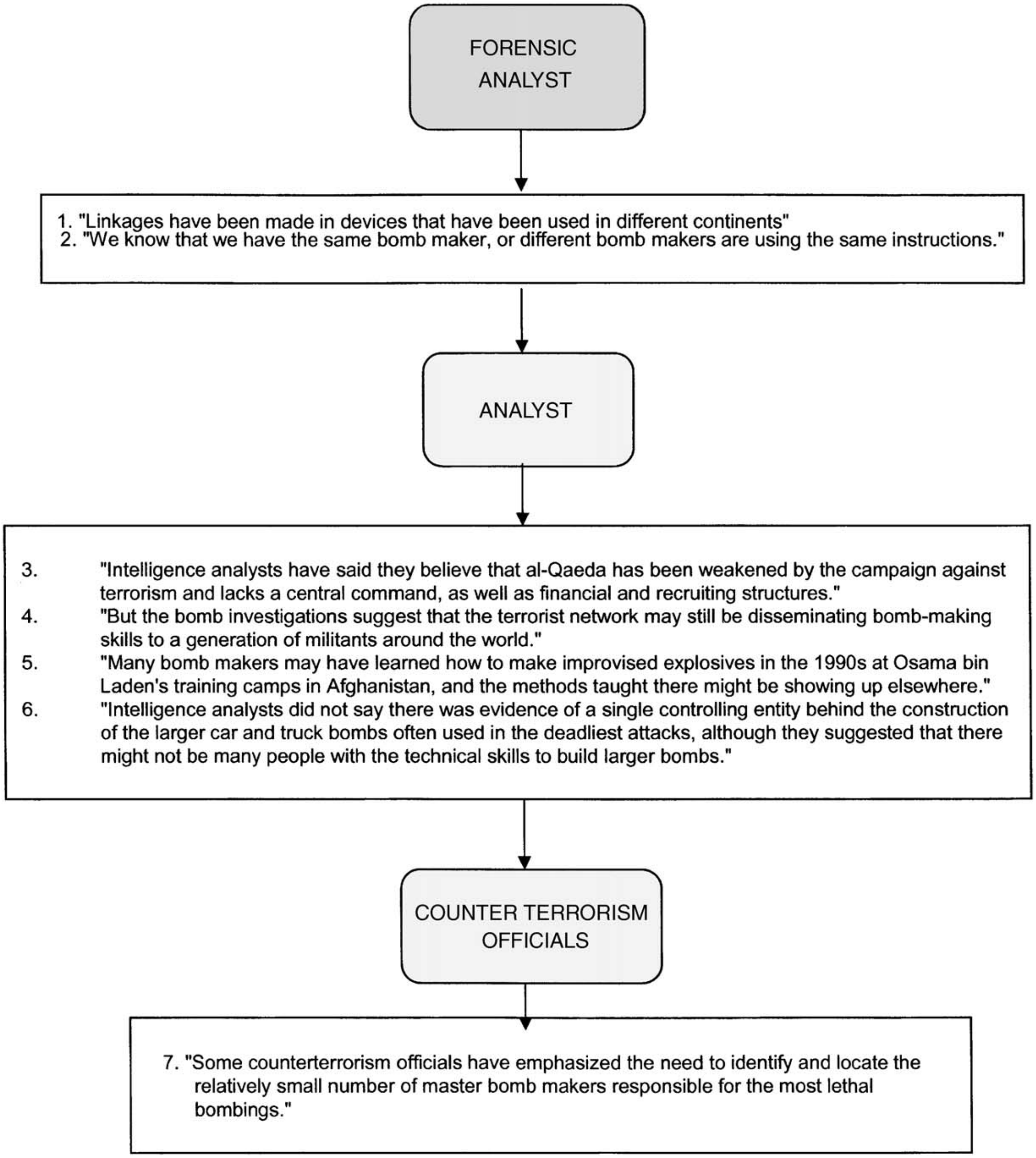

Fig. 1. The decomposition of inferences in this particular intelligence process has a linear structure. It separates clearly the types of knowledge involved and the participation of each agent. In this example, formalisation of communication channels is readily possible through reports or oral presentations.

Example 4. Drug intelligence

The production of intelligence through chemical/physical attributes extracted from illicit drugs seizures still necessitates specific interpretations of links that are only achieved through full integration with the police investigation, crime analysis and other knowledge pertaining more generally to crime science. Databases are under development through different international projects [21–23], but there is still a lack of experience on how the systematic use of such information can provide investigative leads and augment general knowledge about the nature and extent of illicit drug markets. Inference processes are still poorly understood and

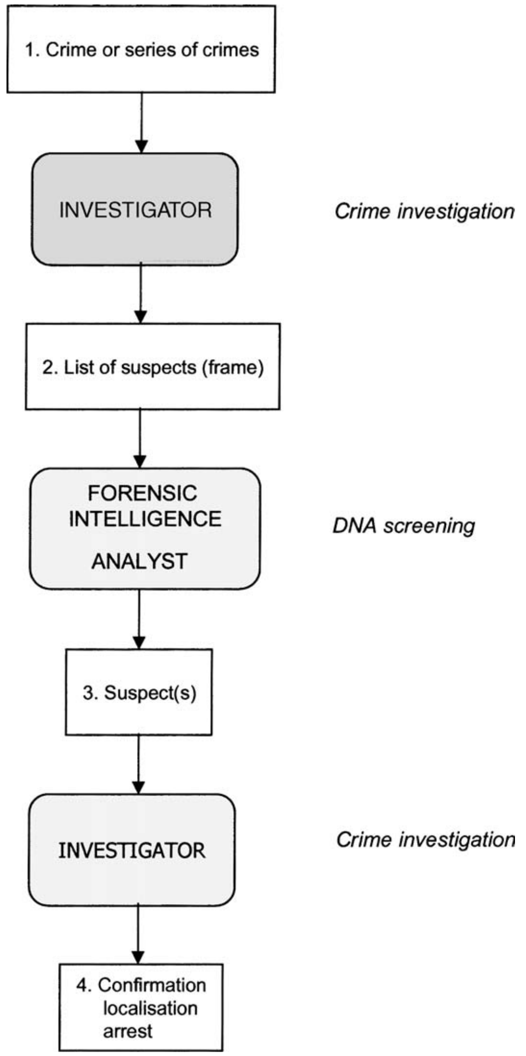

Fig. 2. DNA screening is a common method generally applied for serious cases. The forensic scientist interprets the obtained results as leads for the investigation and must be understood as such. This diagram shows again a linear structure that favours the distribution of tasks, but underlies a more complex communication process carried out during the crime investigation whose nature is still not fully understood and difficult to model.

it is difficult to propose a clear distribution of tasks [23–26]. In such situations, a favourable context must first be created, where intensive communication can efficiently occur between law enforcement officials, analysts and scientists. An iterative process dedicated to the capitalisation of experiences can help increase awareness of the potential of this data, to further design and formalise the division of roles, to identify systematic tasks to be carried out and the communication processes that need to be implemented. Research has shown some potential applications of drug profiling and intelligence [23,24,26] Interfacing structures between forensic laboratories and the police are under development in this area.

7. Full specific implementation for serial crime analysis

One important criminal intelligence process is the analysis of serial crime. It can be seen as an iterative process that accepts new criminal events as its input and distributes them into a structured memory that networks basic pieces of intelligence. This memory is then scrutinised in order to ensure its coherence, detect new relations and suggest guidelines for strategic analysis, investigation, proactive policing or targeted collection of data (Fig. 4).

In this approach, the design of the memory, its architecture and its relationship with the inference structures that underlie its exploration are the challenging questions that have been treated by Ribaux et al. [3,4].

Such a model abstracts from specific implementations that can depend on factors such as the size of the organisation, the structure of the criminality, available expertise and resources, as well as other contextual factors. It has been implemented within a Swiss police department and has been continuously developed over ten years of operation [19,27,28]. It is used in particular for the treatment of high volume crime, but occasionally extends to other types of serial crimes. Important aspects of this system, particularly of the forensic intelligence contribution are summarised further.

7.1. Background

The police force covers one Swiss canton of about 600,000 inhabitants. It has one main city of 200,000 inhabitants (including suburbs) and about 1600 policemen distributed into different organisations (city and canton). Five crime analysts have the responsibility to analyse about 24,000 of all types of reported thefts and to provide tactical and operational recommendations, as well as strategic assessments about analysed types of crimes perpetrated by international organisations. One forensic analyst is in charge of providing intelligence through traces.

7.2. Method: basic principles

Linking crime scenes (Primitive inference 3) (Section 3.3) is obviously a primitive inference in this framework. However, it integrates the idea that this kind of relation can be built inductively, through different sources of data: modus operandi can be first compared and a possible link can be then confirmed by forensic case data such as shoemarks, DNA, earmarks, toolmarks or numeric data extracted from mobile phones. Alternatively, starting from forensic case data and challenging hypotheses through geographical assessment is another valid reasoning process in this model.

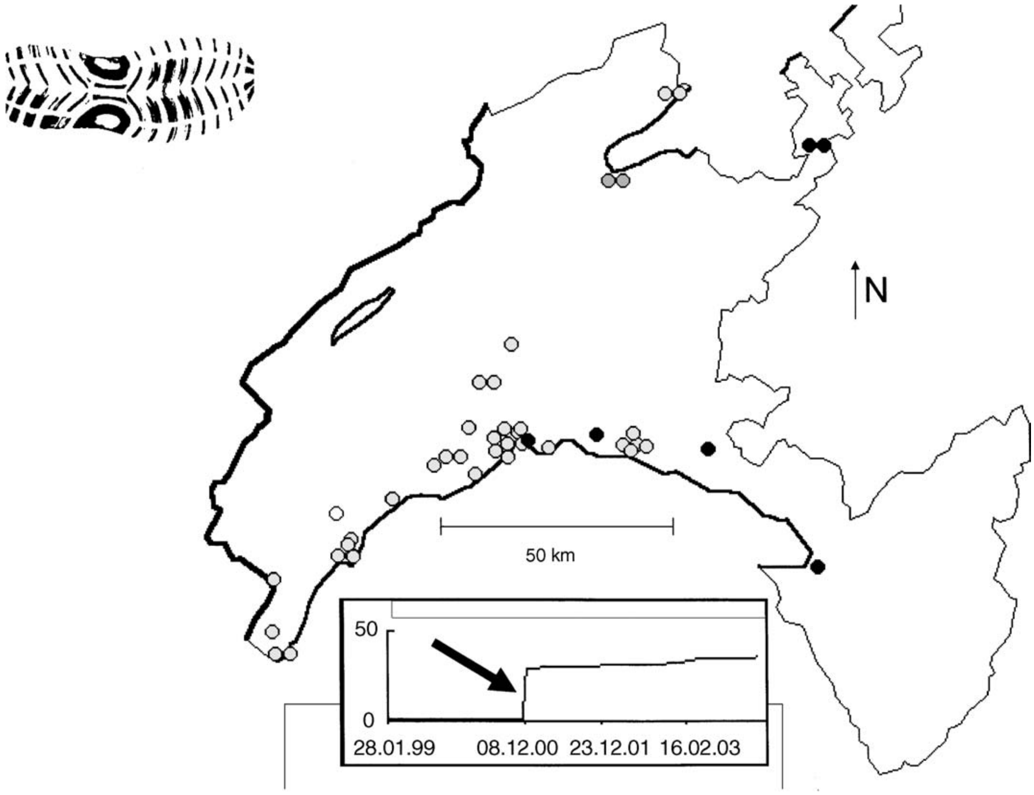

Fig. 3. Each dot on the map represents one burglary where a shoemark coming from a shoe of the same make and model has been collected. The period under consideration is 5 years, from 1999 to 2004. The white dots represent cases at the beginning of the period. Dots change of colour every 30 days in order that black dot represents cases at the end of the period. This picture shows that, in an interval of 2 weeks, such traces have been collected 33 times. An interesting geographical patterns results from this analysis that is entirely independent from modus operandi or other contextual considerations.

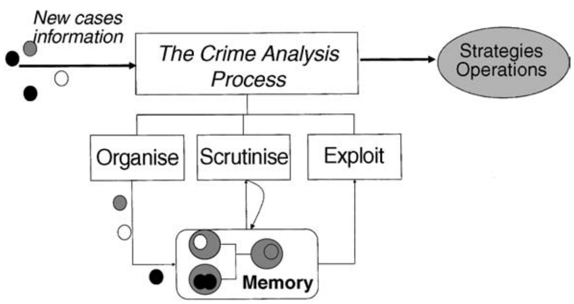

Fig. 4. Representation of the serial crime analysis process that integrates data and information coming from different sources into a structured memory which is systematically updated, scrutinised and analysed in order to ensure its coherence and provide intelligence. This memory is an abstraction of the shared knowledge belonging to an organisation pertaining to criminality and its evolution, as well as about criminals and suspects. Its understanding helps to derive efficient methodologies, distribution of tasks and computerised tools in function of the specific organisation in which a crime analysis and forensic intelligence system has to be deployed [4].

The comparison process is based on the following principles:

- cross-comparison of all the data collected on each crime scene is not possible and should thus restrict us to the most promising set of data;
- there is a limited time for each comparison, invalidating the possibility of applying a full identification process in each situation;
- experience shows that if a criminal has previously been convicted through the exploitation of a particular type of evidence or has knowledge of some forensic techniques, he will adapt his modus operandi in order to avoid leaving the same trace again. However, following Locard's exchange postulate, due to the intensity a criminal act requires, he probably will leave some other exploitable signs of his action. By defining priorities and from an intelligence point of view, it can be more efficient to augment the number of types of traces collected and simplify their individual treatment, than putting all the effort in the extensive exploitation of a single type of trace.

Thus, of importance is the detection of a promising set of criminal events which could then be scrutinised further. This could occur through the combined use of different types of forensic case data. Trends analysis and geographical clustering based on forensic case data are particular instances of such a type of inference and can be applied to a great variety of evidence types, as shown in Example 3 [3].

Intensive daily information exchanges are encouraged between crime analyst, crime investigators and the forensic analyst. This is realised through various formal and informal channels.

7.3. Tactical assessment meeting

Once a week, two members of each unit participate in a tactical assessment meeting that mainly serves to manage current investigations. The role of forensic intelligence in these meetings is crucial since it contributes to providing a general picture of the crime situation, highlights the existence of current series, their size, nature and geographical distribution. This helps in deciding priorities and distribution of tasks among specialised or local units. Actions for each unit results from these meetings. For the forensic intelligence unit, a typical task resides in asking for comparisons of collected traces with databases located in other jurisdictions and even in other countries. For instance, if crime analysts and investigators suspect that the perpetrator of one case comes from a specific country, finger marks collected will be submitted to the foreign AFIS system.

7.4. Daily scene of crime officer meeting

Crime analysts participate in the daily scene of crime officers meeting. All the attended cases are explained and traces collected, modus operandi and other contextual information are presented in an intelligence perspective. Moreover, crime analysts frequently alert on the existence of new or notable modus operandi or current series that influence priorities on the type of scenes to be attended and insight on what has to be searched.

7.5. Systematic processes

Some systematic processes have been formalised. For instance, the results of systematic comparisons of shoemarks and other traces are automatically communicated to the crime analysis unit and integrated into a shared memory (see below). Results coming from the centralised fingerprint and DNA database are also systematically integrated with all other types of information. Of particular interest are the links detected through the use of the DNA database that helps to detect series and are often at the origin of successful analyses and investigations [8]. One distinct advantage of forensic case data in this perspective is the combining of trace information that lack current personal data that may be subject to legal protection.

7.6. Physical proximity

All the units are physically located in the same building. There is no restriction for data sharing and communication. Daily interactions occur between all three units within this favourable context for encouraging communication.

7.7. Computerised memory

At the level it is described, the memory can be an efficient way to combine the disparate knowledge (which is usually dispersed across the police organisation) without necessitating a full update of the structure but rather by stimulating information and knowledge sharing. Therefore forensic scientists, investigators and crime analysts can all contribute by inputting basic intelligence that arises from their own expertise, knowledge or source of information. Preconditions are necessary to an efficient implementation of such a method since the different participants have the possibility to (partially) act on the memory for and share a mechanism to control its upgrade. Such a shared memory has been implemented through a computerised system that includes facilities for visualising data in the form of relational diagrams and crime maps.

7.8. System assessment

The system is not assessed through a formalised quantified evaluation. However, it is continuously discussed and evolves by capitalising on experiences and through modelling. The implementation of systematic processes arises from the analysis of inference patterns that have been used [2]. The identification of those structures must continue, because they can help model the distribution of roles and tasks, depending on the type of knowledge they are based upon, or the frequency with which they are used.

The creation of such a system has necessitated the full commitment of the management, because a change of attitude results from a very slow and resistant process that exists in law enforcement environments. An efficient control panel has created a high demand that speaks for its value.

The synergy that results from such a methodology in the provision of all forms of intelligence, if appropriately applied, can be very encouraging and can be illustrated positively through the following real example.

7.9. Solving serial crime

During 2002, an important series of burglaries was detected though links provided by the national DNA database. By comparing all the available information, new links were detected via modus operandi and shoemarks. These clarified the picture of the series considerably such that it showed a geographically wide recurrence of cases across several jurisdictional boundaries. This knowledge became the starting point for a deeper analysis of the series that coordinated investigators, forensic scientists and crime analysts of all the regions concerned. This allowed investigations on the same case that had already begun in different police forces to be combined. Similarly, when new cases occurred, all the basic pieces of intelligence were integrated into a single memory. The outcomes were used to target the collection of data and guide investigative efforts. A suspect was very rapidly identified through a fingerprint found at one of the scenes, but it was impossible to localise and arrest him, despite geographical analysis suggesting a likely region of residence.

The knowledge about the series prompted fingerprint and palm print comparisons with poor quality marks that were not previously submitted to the database. This analysis led to further identifications of the same suspect.

The crime analysis team then detected a new case with a modus operandi compatible with the profile of the series, whereby a credit card was stolen and subsequently used to buy food in a shop that was equipped with a CCTV camera. Investigation of the image showed the suspect in the company of a local criminal who was known to the police and easy to localise. Further investigation led to the arrest of the main author of the series.

The investigation and analysis lasted about 6 months overall, from the detection of the series until the arrest of the criminal and was carried out by adding new pieces of intelligence that iteratively consolidated the profile of the series. At the time of arrest, the combination of all this data proved overwhelming and a useful information to consider the case as a whole.

7.10. Strategic assessment

Switzerland is a confederation of 26 cantons (states). The coordination of the different police forces is strategically of high priority in order to fight against mobile habitual criminals. In these circumstances, the content of the memory constitutes a very rich and valid picture of the mobility of the criminals and the extent of their offences. Together with the interpretation provided by crime analysis, it can efficiently be used to set priorities, and coordinate the deployment of resources between the different law enforcement agencies. It has demonstrated a means to bridge the gap between strategic and tactical intelligence.

7.11. Interagency exchanges

The development of forensic intelligence becomes far more difficult when different agencies are involved. It can potentially cause different forms of linkage blindness [12]. All the key aspects highlighted do not exist at this level. Moreover, the background can greatly differ between agencies: priorities, resources, organisation, constraints, computerised system, awareness, criminality, etc.

A crime analysis structure has been implemented at a regional level covering five Swiss cantons. Computerised communication channels, monthly meetings, uniform classification systems and systematic and punctual exchanges have been approved by all the participants. From an intelligence perspective, all DNA links, together with the context of the case, are centralised and added to the shared computerised memory already described [8]. Systematic shoemark comparisons are also performed through specific meetings three times a year. The results are further analysed by crime analysts. Punctual comparisons are performed, depending on the analysis of the current situation. Finally, local crime analysts have implemented similar relationships with their own forensic departments. The situation is far from ideal because most of the data is still scattered among separated databases and there are still methodological confusions and recommendations that necessitate the coordination of resources which are not always approved. However, within the existing organisations, methods are regularly updated and interagency successes are regularly obtained.

8. Conclusion

Forensic intelligence could participate more actively in the intelligence debate if its scope could be better defined and properly situated within the criminal justice system and security structures. An intensive modelling approach has been initiated in order to better understand why forensic case data can provide solid and timely intelligence in a great variety of situations, to eliminate the ambivalence in the role played by forensic science within the criminal justice system and to provide guidelines for implementation. It has been shown how a classification of commonly used inference structures can form an appropriate basis of this framework, because it largely abstracts from specific law enforcement environment.

From another perspective, typical intelligence processes can be scrutinised in order to detect where and when the analysis of forensic case data could be more extensively used. A multi-agent perspective has been chosen to help comprehend the complexity and nature of the communication processes required between the different contributors to the global resolution of problems.

An approach for such an activity applied to serial crime analysis is described. Such an approach has resulted in a method implemented in a Swiss police department that efficiently combines knowledge coming from investigators, crime analysts and forensic scientists. The resultant synergy has shown remarkable successes for serial crime analysis and investigation. In other countries, various forensic intelligence units have been developed. The sharing of experience will be a critical issue for a better understanding of the nature of the processes involved.

Acknowledgments

The authors wish to thank all the police of the French part of Switzerland for the support they provide to this approach.

Alexandre Girod, the Chief of the Forensic Science Department of the Police Cantonale Vaudoise is particularly stimulating the operational development of forensic intelligence. One of the figures has been directly extracted from his work on the geographical and temporal distribution of shoemark patterns.

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