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Crime scene investigation as distributed cognition*

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Crime scene investigation is a form of Distributed Cognition. The principal concept we explore in this paper is that of ‘resource for action’. It is proposed that crime scene investigation employs four primary resources-for-action: (a.) the environment, or scene itself, which affords particular forms of search and object retrieval; (b.) the retrieved objects, which afford translation into evidence; (c.) the procedures that guide investigation, which both constrain the search activity and also provide opportunity for additional activity; (d.) the narratives that different agents within the system produce to develop explanatory models and formal accounts of the crime. For each aspect of distributed cognition, we consider developments in technology that could support activity.

Keywords: crime scene investigation, distributed cognition, narrative, technology

1. Introduction

The crime scene investigation process begins with a crime being reported, and culminates with the apprehension of the perpetrator (or the exhaustion of all lines of enquiry) and the crime being filed. The following sequence of events outlines this process:¹

1. Crime committed, crime reported, incident created.
2. Scene investigated, evidence retrieved.
3. Offender caught or identified and charged.
4. File compiled by File preparation, receive all information on the enquiry, from the Police: Witness statements, Crime Scene notes, Forensic reports, etc.

5. File sent to CPS, decision made whether to prosecute.
6. Decision made to continue, file made available to defence barrister.
7. Defence or prosecution may request additional examinations during the course of the trial.
8. All information, used and unused should be made available and declared using an “unused evidence” form (submitted with the statement).
9. CSI, Police, etc. are requested to submit a statement of actions to the court. On some occasions if counsel has questions concerning the evidence they will call the witnesses to court, along with the relevant evidence.

At each stage of the investigative process, evidence needs to be collected, recorded and disseminated to the next link in the investigative chain (Smith et al. 2004). In the UK, decisions are made concerning the admissibility of evidence by a variety of organisations, e.g., Crown Prosecution Service, the Courts, The Law Officers (i.e., Attorney and Solicitor General), The Lord Chancellor’s Department, and The Home Office. Clearly, crime scene investigation is a distributed process through which different organisations become involved in the evaluation of evidence. Ultimately, it is the CPS that prepares cases for Court; to ensure that prosecutions started by the police involve the right defendants prosecuted on the right charges before the appropriate court,² and to put cases through “the Tests”.³ Thus, when the CPS receives a file from the police, the prosecutor will read the papers and then a decision is made whether there is enough evidence against the defendant.

2. Distributed Cognition

Cognitive activity can be performed by more than one ‘agent’ (humans or technological) interacting within a system. This is certainly true of crime scene investigation, in which, evidence is likely to be collected by one group of people, analysed by another group, and interpreted and presented to Court by another group. Each group specialises in some aspects of the activity, and each group is subject to scrutiny in terms of its ability to perform its specialised role. Should it be possible to question the reliability of any of these activities, then the evidence can be invalidated.

For Distributed Cognition researchers, objects can be viewed as ‘resources for action’, i.e., the design, appearance or functionality of specific objects or the layout of specific environments will call to mind particular actions for the person (Marti 2000; Artman and Waern 1999; Bang and Timpka 2003; Busby

2001; Garbis and Waern 1999; Hutchins 1995b; Hutchins and Klausen 1998; Nemeth 2003; Seagull et al. 2003). The actions could be physical, e.g., in the sense that some objects might 'afford' picking up, or could be cognitive, in the sense that some objects might support a particular form of information-processing, e.g., price labels on foodstuffs in a supermarket might support arithmetical calculation. From this point of view, objects can be responded to in terms of physical or cognitive actions, and their presence in the world influences the activity of the people around them. The manner in which actions are performed will, of course, depend on the appearance (or States) of the objects and the Goals of the people.

2.1 Wright et al.'s resources model

Wright et al. (1996, 2000) elaborate the Distributed Cognition notion of resources for action into a 'resources model'. This model aligns particular resource types, defined in terms of abstract information structures with an interaction strategy, to propose how changing the configuration of resources can alter a person's activity. Thus, the model has three components:

- i. **Abstract information structures:** The Abstract Information Structures cover the *plans* put into effect by agents, the *goals* held by agents, the *possibilities* for performing specific actions, the *history* of previous actions, perceived *action-effect relations* and the *state* of objects during the course of interaction.
- ii. **Representations:** Each Abstract Information Structure can be represented in a variety of ways. Plans could be written down as procedures or instructions (or could be learned and memorized by the agent); possibilities could be presented as a set of alternative options, such as a menu; history could be recorded as a list of previous actions; state could be described by the current action of a particular product. Thus, representations are used to either convey (through the design of the artefact) or infer (through the action of the user) one or more of the abstract information structures.
- iii. **Interaction strategies:** Interaction between person and artefact is a cycle of acting and checking. The person sets out to achieve a goal and looks for information from the object that looks relevant to that goal. There are several generic interaction strategies each of which draws upon a subset of abstract information structures, e.g., Plan following (plan, history, state), Plan construction (goal, possibilities, action-effects, state), Goal matching (goal, possibilities, state), History-based elimination (goal, possibilities, history).

Table 1. Relating objects of investigation to abstract information structures

	State	Goal	History	Plan	Possibility
Environment	Visual inspection	Inspect	Similar scene	Look at scene, take photographs	Contain surfaces/objects
Surface	Visual inspection or treatment	Search	Similar scene/sequence of search	Procedure/technique	Contain evidence
Object	Visual inspection or other analysis*	Collect		Collect/Record	Contain evidence/is evidence
Sample	Other analysis	Send	Database of samples	Record	Contain evidence
Analysis	Other analysis	Result		Record	Evidence can be got
Identification	Result of analysis	Identify	Previous convictions/ Stored on database	Identify	Place person at scene or for activity
Report	Photograph/lab results/Result of analysis/ Identification	Summarise	Collect previous analysis and investigation	Collate/ Present	Complete, coherent account of a crime

*'other analysis' covers any non-visual activity, such as chemical analysis (DNA, fingerprint), or through microscopy (fibres)

The choice of interaction strategy will clearly depend on a host of contextual features. However, the point is that the strategy influences the selection of abstract information structures to which the person will attend. This implies that following one interaction strategy in preference to another would also predispose the person to ignore some of the abstract information structures. This, in turn, suggests that there is a relationship between the action followed and the resources selected, as well as the earlier assertion of a relationship between the resources selected and the action to follow. In some cases, an object-in-the-world will serve as a resource for action and offer the possibility of performing a particular action; in other cases, the course of action (as defined by an interaction strategy) will lead the person to look for particular resources in order to perform particular actions. The manner in which the possible abstract information structures are represented can vary according to the context in which an action is being performed (see Table 1).

2.2 Implications for technology

As part of the MsSAM project, we are developing a variety of technologies to support CSI. Throughout this paper, examples of these technologies will be discussed with reference to particular sections (although the relevance of the technology will probably extend to other sections). From the perspective of Distributed Cognition, it is proposed that there are four main types of resource for action within crime scene investigation: the environment itself, which affords particular forms of examination; objects within the environment, which afford interpretation as evidence; the procedures that govern crime scene investigation, which afford application to different environments; the narratives constructed during the course of crime scene investigation, which afford both hypothesis formation and explanatory models of the incident. There is an ongoing debate within the CSI community as to how much the activity of a crime scene investigator can be considered as 'search' and how much it is a retrieval activity. Leaving aside the question of how retrieval can be performed in the absence of search, the issue at stake is how much leeway should be granted to the CSI in terms of interpreting objects in terms of evidential value. One school of thought argues that the role of the CSI is to recover items in a manner that is as neutral as possible, to allow interpretation to be performed by other specialists, while another school of thought views interpretation as central to the CSI role. It is not the purpose of this paper to argue for one view or the other, but it is worth noting the current debate.

In terms of applying this work to the design of technology to support crime scene investigation, we can begin to generate some specific design guidelines. The resources for action that are employed in crime scene investigation need to be represented in a manner that can support shared activity, provide some input to formal reporting, and be adaptable to different contexts. This means that the representations are required to be, in the words of Nemeth et al. (2003: 381), "reliable, informative, efficient, clear, accurate, and malleable". Seagull et al. (2003: 1521) propose five functional requirements for technology that can be employed in Distributed Cognition systems: "(a) serve as a common referent for communication, (b) provide a communal memory tool for planning, (c) serve as catalyst for collaborative and Distributed Cognition, (d) allow parallel manipulation for multiple user-groups, and (e) allow flexible content-reconfiguration". To these requirements, we can also add the need to minimise (as far as practicable) the risk of contamination to a crime scene, and the need to minimise (as far as practicable) the interruption caused by recording of findings, e.g., through note-taking.

3. Narratives as resource-for-action: Synthesising multiple representations

The notion that 'narratives' play a role in criminal investigation is certainly not new. Crime-fiction writers, from Poe, Collins and Doyle to present day, have their protagonists relate the chain of events and association of evidence that incriminates an individual. More recently, there has been interest in the ways in which narratives are used in Court (Barry 1991; Brooks and Gerwitz 1996). An obvious example of the use of narrative lies in the manner in which eye witnesses produce accounts of incidents. It is well known that such accounts are often problematic and subject to a range of confounds, biases and distortions (Loftus 1979; Wells 1985; Wells and Olson 2003). In this paper we are not going to engage with the large literature relating to eye witness testimony. More recently, there has also been a great deal of interest in the manner in which juries makes use of narrative to 'frame' events and to make sense of evidence and testimony. Pennington and Hastie (1986, 1988, 1993; Hastie and Pennington 1995) state that jurors use 'story models' to organise information in court hearings. The proposal is that such story models both help and hinder assimilation of information by framing the available information into coherent (for the listener) accounts. This might lead to associations being drawn which are inappropriate or to links being missed.

The concept of narrative is also used to consider how evidence is presented in Court (Conley and O'Barr 1990; Engestrom 1998). In particular, the notion of 'anchored narratives' has been used to show how the manner in which information is presented, discussed and summarised during the process of a trial can be analysed according to concepts from semiotics and narrative psychology (Jackson 1988, 1990, 1995, 1996; Wagenaar et al. 1993). While such approaches are not without critical commentary, e.g., Morley (1996), they do provide a means of addressing the ways in which people attempt to make sense of evidence. This issue of 'sense-making' as the interpretation of aspects of the world to produce "meaning" that can be communicated and shared is central to the entire process of criminal investigation, from reporting a crime to recalling incidents to reporting and detailing evidence. A particular challenge for our work is the notion that sense-making occurs in discourse rather than simply in minds or representations. Sense-making is a collaborative process in which different agents contribute to an interpretation of events. What is particularly difficult to articulate is a 'discourse' that covers such a highly distributed system as CSI, in which all agents have different roles and expertise, and focus on different aspects of evidence gathering and analysis. This raises the possibility of

using technology to create and encourage a 'collective intelligence'. Additionally, the notion of sense-making accords very well with the notion of 'resources for action' outlined above, i.e., people make 'sense' of the world

...by accepting stimuli from their environment, including others around them, and interpreting what these stimuli mean. The subsequent actions, including probing of the environment, lead to additional stimuli, which must provide meaningful affordances to grab attention, and subsequent processing. Human and non-human agents must be attuned to relevant affordances in order to interpret them, to act based on them, and to probe for additional stimuli (Nosek 2001: 219).

3.1 Narrative and argument

The procedures that govern criminal investigation require formal reports to be produced according to specified standards. Thus, an Incident Log records initial details of the crime; a Crime Report compiles all the information relating to that crime; Contemporaneous Notes are recorded by Scene of Crime Officers and these are written into a Scene of Crime Report. In contrast, many investigations draw upon eye-witness testimony. The content and structure of such reports will not be subject to any 'formal' rules, but depend upon the witnesses own account. This contrast between formal and informal narratives speaks to the contrast between narrative and argument proposed by Bruner (1992, 2002). In this concept, a narrative could be viewed as a fairly loose, informal discourse that contains sufficient information to illustrate an account, while an argument could be viewed as formal representation of objective evidence. One way of thinking about this distinction is that the argument represents the paradigmatic 'information-processing' model of cognition, in which interpretation follows a definable logic and can be seen as objective; while narrative is a form of discourse in which people create stories to explain and interpret information. As Boland and Tenkasi (1995) point out, in distributed cognition, it is likely that different agents will create narratives in different ways, i.e., that various experts might have subtle differences in their definition of aspects of the environment. This could suggest that having a 'standard' form of reporting of evidence (which, as we shall see below, is something being implemented across UK criminal investigation) without an opportunity for discussion could be problematic.

3.2 Narratives and reporting of incidents

If we assume that most police activity takes place in response to a telephone request for help, then the work of Zimmerman and colleagues is instructive (Whalen and Zimmerman 1990; Zimmerman 1992). Consider the following extract of narrative from a call reporting an 'incident' to an Emergency Call Centre.

Table 2. Extract of dialogue between caller and district call handler

1	Dis	.hh Midcity emergency
2	Caller	.hhh Yeah uh(m) I'd like tuh: -report (0.2) something
3		weir:d that happen:ed about:t (0.5) uh(m) five minutes
4		ago, 'n front of our apartment building?

In this extract, the Caller is seeking to engage in a dialogue to define the required response, i.e., "something weir:d" that the Caller had witnessed and which might require Police response. The Caller is providing an invitation to the Call Handler to discuss the incident and determine appropriate actions. In this example, the script is being written as the conversation progresses, so the initial steps are about determining what 'ground' is available and how it might be made common. The Caller does attempt to provide some basic 'script' information (in terms of time, i.e., "five minutes ago" and location, i.e., "'n front of our apartment building"), but these could also be viewed as invitations to the Call Handler to respond by asking for more information, e.g., precise time and address, etc. For the Caller this might be a way of defining the appropriate narrative to account for the incident; for the Call Handler this might be a way of gathering sufficient information to determine whether a crime (or event worthy of investigation) is being reported and what sort of response is required. If the response is immediate, because of suspects on the premises or immediate threat to life, then the Call Handler might seek to establish the location and initiate a response in parallel with gathering additional information.

The Call Handler will, typically, enter some information according to the structured format of an Incident Log (usually on a computer). The information will be made available to other operators, who, in turn, will manage the dispatch and activity of Police Officers (including Scene of Crime Officers). Table 3 illustrates the sort of entry that might be made in such a computer system.⁴ This extract illustrates three points of interest. First, the text in capitals represents a 'real-time' summary of the dialogue between Operator (AF01) and Caller. In order for this to happen, there will be dialogue similar to that shown in table two, and this dialogue will have established a 'common-ground' which

Table 3. Extract from Incident Log

1108	8169	AF01	THEY HAVE PERSONS ON PREMISES WHO ARE RESPONSIBLE FOR BREAKING INTO LOCKERS. THEY ARE THERE NOW.
1109	8169	AF01	THERE ARE 2 MALES RESPONSIBLE THEY ARE WALKING AROUND THE FITNESS CLUB CALLER CAN POINT THEM OUT
1111	1583	HQ00	XX75 Assigned (1111) Arrived (1115) Released (1125) Cancelled ()
1111	8169	AF01	CALLER WILL BE AT GYM RECEPTION AND CAN IDENTIFY THE MALES. HE HAS NO DETAILED DESCRIPTION AT PRESENT

can be entered into the computer. This real-time entry means that there may well be duplication of information, e.g., the repetition of phrases emphasising that the suspects are on the premises which could require an immediate response ('persons on premises', 'they are there now', 'they are walking around the fitness club'), and the inclusion of unsubstantiated information, e.g., 'who are responsible for breaking into lockers', 'there are 2 males responsible' (these entries do not assume proof of responsibility but indicate the Caller's suspicions and the fact that there is a crime to investigate). Second, the entries in capitals form a record that can be shared by other operators, who can assign units to the incident. For example, operator HQ00 assigns unit XX75 to respond to the scene. Communication between operators and units is typically through radio communications and involves another set of dialogues. Third, the entire log forms evidence of the investigation that could be called upon in Court, and so needs to be a complete account of the activity (hence, the need to enter information in real-time).

The log records information from callers as well as the activity of the three units who had been dispatched to the site: one unit interviews a 'Male' leaving the fitness club [THE MALE GOT INTO A VEHICLE OUTSIDE THE BARRIER AND MADE OFF — UNKNOWN DESC OF CAR]; one unit checks the building [NO SIGHTING AT THE MAIN BUILDING]; and one unit finds that the suspects [LEFT VIA FRONT ENTRANCE APPRX 40 MINS AGO], together with the names, addresses and previous history of the suspects (which we need not consider in this paper). Following this activity, a decision is made to request scene of crime support [CAN WE PRINT FOR SOCO — TO PRINT THE LOCKERS #5 AS BEEN TAKEN]. Subsequently a Crime Summary Report is printed, as shown in Figure 1.

Crime incident number	Offence details	Beat	Location	Times/day/date	Investigating officer	State of crime
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Figure 1. Crime Summary Report headings

It is apparent from Figure 1 that very little of the information collected during the activity in the Incident Log is transferred to this report. We have a description of the offence and its location that could be useful to the SOCO, but little else. The Incident Log might be shared between people who are working on the response, but this does not mean that it supports collaboration. However, it does imply that current practice tends to place people as 'gate-keepers' for information, which, in turn, encourages redundancy of data entry. For example, much of the content of the incident log will be entered in the personal issue log books of the officers involved.

3.3 Sharing narrative

The notion of 'sharing' narrative between individuals, such as Call Handler and Caller discussed above, might not simply be a matter of establishing and maintaining common ground. Rather discourse raises and develops new material, with the aim of determining what might need to be shared. In terms of Distributed Cognition, the Log provides a resource for action for determining general classes of information. However, it is also apparent that the role of this Log is in the immediate performance of activity, rather than an archive to be passed on to other people. At present, sharing is real-time by voice or via a shared terminal. There is little use of graphical capability for sharing or sharing over longer periods of time or between people not immediately involved in the response, such as CSI. When information is shared, it is often the 'fixed' elements, such as location, time, names, rather than interpretative elements, such as action or motive, but could include Contentious details, such as ID of a suspect.

3.4 Implications for technology

In terms of our work, there are two broad approaches to the sharing of 'narrative' that we consider. The first simply focuses on the manner in which the Incident Log could be made available in more detail to the investigator, the second relates to capturing the investigation of a crime scene. Using details from the incident log, and updating it to the various personnel in an investigation

is made easier with the introduction of TETRA into emergency service operations. In effect, this represents a broad-band communications channel, over which text, images and voice can potentially be circulated. More interestingly, this channel can be set-up to provide 'talk-groups'. This means that some information can be shared within a defined group of people. From this implementation it could be possible to allow 'communities of knowing' (to use Boland and Tenkasi's (1995) phrase) to share task specific information. For example, from the discussion following Table 3 (above), if it was known that the suspects had left the building, then it might have been unnecessary to question anyone else as to their whereabouts.

During an initial inspection of a scene, the CSI could produce an audio commentary on a video. If this was available to colleagues away from the scene, such as the Crime Scene Manager, then discussion on the form of search and recovery could take place. For example, the CSM might advise on checking only Points of Entry or might advise on recovering specific items. In this manner, the CSI and CSM would have a form of video-conference that could support discussion of activity. The video could also be used as the basis for briefing other people in the investigation team. While the notion of video-conference is commonplace, the idea of situating such communication at the scene, i.e., via wearable computers we are developing, is less well established.

4. The crime scene as a resource for action: How environment influences search

An initial step in assessing a crime scene can be crudely described as the recognition of objects as having evidential value. In other words, an environment contains a multitude of things that may or may not be relevant to the investigation. For crime scene investigation it is not feasible to evaluate everything for its potential to offer evidence, e.g., due to time constraints, condition of environment or objects, possible association of objects to activity. Consequently, there is a need to conduct some initial classification and screening of the scene and to focus the attention on objects of potential evidential value.

4.1 Narrative in the collection of evidence

The purpose of examining a crime scene is to formulate a hypothesis based on all the available evidence, therefore understanding the most likely course of events that has resulted in the observed circumstance (Jamieson 2004). As the

search of the crime scene progresses, Schraagen and Leijenhurst (2001) suggest that forensic investigators use narrative to determine how best to collect evidence. The narrative might include expectations concerning evidence and expectations concerning the crime. In their study (in which trainee forensic investigators work at a simulated crime scene), they showed that 'experts' use this narrative to select appropriate heuristics to guide their search for, and interpretation of, evidence. The process by which items are selected can be considered analogous to directed search. This implies that search involves not only seeing something but also developing an expectation that something will be present.

To some extent, one could consider the crime scene as 'affording' (in Gibson's (1950) sense) items for investigation. The environment itself, therefore, becomes a resource for action in that it supports the search for evidence, not merely as a repository of things to be found but, more importantly, as an associated set of objects for investigation. The crime scene would have points of access, it would have opportunities for movement, it would have locations at which fibres or other samples might be captured, and it would have various objects that might have been handled during the course of the crime. Each of these would afford a particular response from the CSI and searching for each of these might be influenced by the expectation of particular affordances. Thus, an experienced CSI is likely to 'see' a suitable surface for fingerprints, rather than merely a table or windowsill or a good place to look for fibre samples rather than a splintered door-jamb.

The internal model of the CSI would relate objects according to a particular interpretation of the crime, the environment and other factors, such as weather conditions. Thus, CSIs might make more of a conscientious search for footwear marks according to the weather. In the Autumn/Winter months, when the ground is wet and muddy or covered in snow, footwear marks will be more readily apparent than in the Summer months when the ground might be dry, hard and resistant to impression. Similarly, the expectation of finding fingerprint marks increases as glove-wearing becomes less comfortable during the Summer or might also increase when small objects or containers that are difficult to open are found. An experienced CSI investigating the scene of a break-in may well walk around outside the building to determine the likely point of entry (POE) and routes to and from the building. This then guides the search to specific locations. Once inside the building, the CSI will look for obvious signs of a route from POE through the building, e.g., as indicated by the direction of footwear marks on the floor, or whether footwear marks are on furniture, windowsills etc., or whether objects have been moved or displaced.

In terms of the abstract information structures and interaction strategies of Wright et al. (1996, 2000), one can consider the environment to support the action shown in table one. Furthermore, the manner in which the environment is represented, for later discussion or examination, can also be considered. Photographs, sketches and brief notes are ways in which the CSI can off-load the burden of remembering details of the scene by recording them for later use. The process of creating notes, photographs and sketches also supports a particular course of action, viz. a top-down approach to the examination in which a global view is taken prior to homing in on specific items of interest.

4.2 Implications for technology

For the consideration of an environment, it might be useful to have some knowledge of previous investigations, e.g., of that type or in that area. Traditionally, this would be the province of the experience gained through years of practice, possibly in one region. However, if one assumes that not all CSIs will have similar experience, that shift in patterns, area of coverage and mobility might mean that sharing of information is less easy than in the past, then having some shared repository of previous crimes could be useful.

By logging activity and evidence against a location, it could be possible to support to collaborative activity over time. For example, we take a photograph of a scene, track an investigator's movement around the scene (e.g., through Global Positioning System or local positioning) and superimpose this track onto the photograph. This is illustrated by Figure 2. The annotation can be supplemented by additional material relating to the activity, e.g., recover item, or analysis (Baber et al. 2005a, b; Cross et al. 2004).

The annotated photographs will serve as a record of activity. However, at a deeper level, they could function as 'boundary object's (Star 1988; Boland and Tenkasi 1995), i.e., representations that provide a common frame of reference for discussion. This frame of reference could, for example, be used to guide discussion about procedure, e.g., why did you do X?, or to interpret activity, e.g., where was item Y recovered? Of particular interest to our work is the relative significance of graphical annotation in contrast with textual annotation. We feel that greater benefit accrues from graphical annotation than text, which is supported by the work of Guibert et al. (2005).

Whilst the use of annotated photographs provides information on a specific scene, it does not easily allow comparison across scenes. An obvious approach to this problem would be to create a database. However, we have decided against this for several reasons, the principal being the need to have some

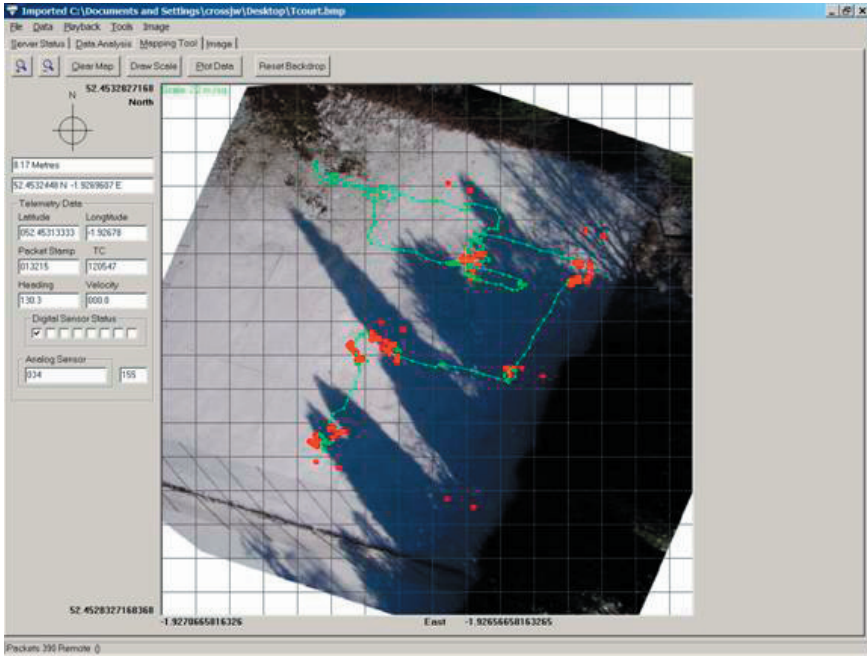


Figure 2. Using position and activity of investigators to annotate a photograph. A photograph (taken from the roof of an adjacent building) forms the background for the plot of position (light dots) and item recovery (dark dots) performed by an individual.

notion of data structure to construct the database and requiring querying of the data. Our intention is to have a means of storing information in as free a form as possible, while allowing as automated retrieval as possible. To this end, we employ Case-Based Reasoning (CBR). For example, an entry contains an address and method of entry. This is submitted, and matching performed which reveals that the same method of entry has been used on properties with similar post-codes. This might suggest a related collection of burglaries using the same modus operandi.

5. Objects as resources for action: The affordance of evidence

A central tenet of Distributed Cognition is the notion that the representations that are manipulated and exchanged by the agents within a system, make up the system's 'mental state' (Hollan et al. 2002; Flor and Hutchins 1991). A significant aspect of crime scene investigation lies in recognising the objects in

the scene as potential external representations. Rather than having the information displayed to the investigator (as is the case with many of the technologies considered by distributed cognition research), the investigator needs to perceive the objects as representing some useful information. Thus, a footprint becomes useful if it can be lifted from the scene and if it can be interpreted in the context of a particular activity at the scene. Whereas much of the work on Distributed Cognition considered earlier in the paper focussed on the manner in which artefacts were designed and used to represent information, this is not the case for crime scene investigation. The objects for investigation are not given, but need to be discovered and translated. Having conducted a search, and determined the relevance of specific objects, the next step is the examination of these objects. In this step, one can consider that the objects afford (in Norman's (1988) sense) examination. In other words, the appearance of an object, coupled with the experiences of previous similar objects, affords certain activities. These activities might range from simply collecting the object and storing it for later display, to treating the object in order to allow collection for later examination in the laboratory.

In addition to objects themselves serving as representations, the investigator will also be making representations, e.g., in the form of notes, photographs, reports. For the purposes of this paper, we propose a simple dichotomy between those external representations that are used to support activity-in-the-world, which we term 'informal', and those that are mandated by procedures or organisational requirements, which we term 'formal'. During the investigation, the CSI will complete various documents. Table four shows some of the six important categories of documentation that are considered applicable to any search, in terms of their possible narrative type (formal or informal).

The UK rules relating to disclosure of evidence from a crime scene means that any records made by an investigator must be made available to both defence and prosecution counsel in court.⁵ Disclosure entails maintenance of carefully logged records reflecting specific time points in a scene investigation and in relation to other actions. It also means that recording will be made in a manner that reflects as much certainty as possible, with as much supporting evidence as available. If there is doubt or uncertainty, then the evidence could easily be called into question. *All* material collected at a crime scene ought to be disclosable. However, this does not mean that all material *will* be disclosed (but it must be available, if so required), e.g., not all of the photographs collected during crime scene investigation will be submitted as evidence. The reason for this might be technical, e.g., poor image quality, or redundancy, e.g., several versions of the same view, or quantity, e.g., don't submit too many images, or

Table 4. Documentation as Narrative Types

Artefact	Content	Narrative type
Administrative Worksheet	Major events in investigation	Formal
Description of scene	General appearance of scene	Informal
Photographic log	Record of photographs taken	Formal
Diagram/Sketch	Drawing of scene	Informal
Evidence Recovery log	Record of objects and evidence retrieved from the scene	Formal
Latent print lift log	Record of prints lifted	Formal

relevance, e.g., only submit images that support the report being made. Thus, photographs collected at the scene are ‘informal’ until they have been subjected to a selection process and then the selected photographs become ‘formal’. The photographs must retain their integrity, i.e., not be tampered with if they are to be subject as evidence. This means that the photograph itself does not change, but that its status as an external representation could move from informal to formal. By a similar token, the content of notes and sketches made at the scene remain ostensibly the same, but are copied into a formal version in a crime scene report.

From a broad perspective, one can suggest that the investigation proceeds through initial examination of the environment, on to the selection of appropriate objects to examine and the collection of particular samples. The samples are subject to analysis and the result reported and used in the identification of an individual. In this section, we consider a specific type of evidence (fingermarks) in terms of their role as resources for action.

5.1 Fingermarks

In order for a fingermark that may or may not be visible to become represented as a fingerprint, it needs to be discovered. This can be done by dusting (brushing powder over), or performing some chemical treatment of surfaces that might carry a fingerprint. The selection of an appropriate surface becomes a matter of judgement at the scene; one would not expect to scan all surfaces. Rather, the selection of likely surfaces to look for fingerprints must be performed. Even when a site has been selected, finding a fingerprint is not necessarily straightforward. For example, there might be smeared marks, there might be several prints that overlap etc. At this juncture, the CSI must decide where there are likely to be latent fingerprints, which can be subjected to testing. Some surfaces are not conducive to conventional fingerprinting. The CSI would evaluate

whether items or surfaces are suitable for fingerprinting with powders, e.g., non-porous, clean surfaces, and whether to use flake powders which are less destructive to the surface and surrounding materials and easier to clean, or granular powders e.g. on outside drainpipes, or with chemical treatment, e.g., paper. If the print is visible to the naked eye, it can be photographed as part of a sequential process of recovery, and with the increasing digital imaging capabilities the marks may be captured and sent electronically. However, it is highly likely that the CSI will wish to have a physical lift as well as the digital image.

The process of 'discovering' a fingerprint is not simply a matter of looking with the naked eye. As mentioned above, the surface requires some form of treatment. Observations of CSI suggests that there is often a painstaking cycle of examination, treatment and checking. For example, a bright light shone obliquely across the surface to help visually scan the area for prints. Used in conjunction with the powdering techniques, the light helps reveal contours and ridges in the mark. When using flake powders the process of dusting typically requires the gradual building up of layers, e.g., using small circular motions of the brush, until a satisfactory impression is produced. This is inspected again under the light and if necessary dusted further, until it is ready to be lifted. Lifting involves placing clear sticky tape over the mark and removing. There is research into digitising the process of lifting, i.e., having a camera capture the image of the mark (although it is a moot point as to whether this will ever remove the need to preserve the mark itself through traditional methods).

Once a print has been preserved and recorded, it can be analysed. Analysis might be performed on site or (more likely) at a laboratory remote from the site. The analyst can benefit from knowing some background information pertaining to the print, e.g., the location and orientation of the print. If the print is made by someone wearing gloves, it might be possible to collect a print if the pattern on the material looks sufficiently distinctive — if the same pattern recurs then this might be sufficient to place a person at a particular set of locations.

One can imagine a continuum over which fingerprints might be considered. At one extreme, a fingerprint identifies an individual; at the other extreme, a fingerprint is a mark on a surface that may or may not be visible to the unaided eye. The transition across this continuum, of course, defines the process of crime scene investigation, i.e., the movement from evidence to identification. However, it also highlights some relevant aspects of Distributed Cognition, namely the manner in which phenomena are represented and these representations shared across a system.

1. Person: affords production of latent print;
2. Action: affords making latent print;
3. Surface: affords latent print being held;
4. Powder/chemical: affords latent print being visible/developed print/mark;
5. Print/photograph: affords collection of developed print;
6. Analysis: affords pairing developed print/mark with known individual and affords reducing uncertainty of pairing developed print/mark with person.

The process of collecting a fingerprint, therefore, culminates in pairing the person who made the print (1.) with a known person with an acceptable degree of confidence (6.). In order for this process to be effective, it is necessary to make certain assumptions about the production of fingerprints, e.g., in terms of where, in the environment, one might expect to find such evidence (3.) and what action might have led a person to produce fingerprints in such a location (2.). Having made these assumptions, the CSI seeks to capture and collect the developed print (4. and 5.). From the point of view of Distributed Cognition, each representation could be held by different agents or objects at the scene or during different phases of investigation. The point at issue is how well the crime scene investigation procedures allow sharing and transfer of representations. The selection of a specific 'good' print (at stages 1. to 3.) could have a bearing on stage 5., but it is not always communicated. There might be useful information to be gained from knowing that a print was made on the underside of a window rather than on the ledge or on the glass itself. The transition from 2. to 3. and from 3. to 4., might introduce artefacts into the analysis. Table 5 presents the fingerprint in terms of abstract information structures and representation.

The notion that search involves an internal model was discussed in the section relating to the crime scene as a resource for action. It was proposed that the purpose of the internal model was to provide the investigator with a means by which items could be looked for or the environment scanned. The assumption is that, rather than recovery of evidence being entirely based on the 'objective' search of a scene, there is likely to be some influence of expectation and experience involved in the search. A good CSI will probably recognise these effects and manage them. However, the influence of experience and expectation could even creep into areas of analysis which are usually supposed to be entirely 'scientific', i.e., free from bias. For example, in a recent study of fingerprint analysis, Dror et al. (2005) explored the influence of contextual factors on the matching of pairs of fingerprints. In this study, contextual factors were manipulated by the story and photographs that were used to explain the

Table 5. Relating Fingerprints to Abstract Information Structures and Forms of Representation

State	Goal	History	Plan	Possibility	Representation
Visual inspection of surface either before or after treatment	Find, capture and collect latent prints	Recall previous encounters with similar scenes	Look at scene, use powder or chemicals to reveal print, capture prints, log, pass on to laboratory	Environment contains surfaces and objects that might yield fingerprints amenable to lifting	Surfaces can hold prints, Reveal latent prints, Lifted print held on medium and labelled, Log, Analysis, Interpretation

source of the fingerprints, e.g., crimes with no physical harm to the person versus crimes with extreme physical harm. The study showed that in cases where the fingerprints were unambiguously different, there was little effect of context. When the fingerprints were ambiguous, i.e., when the certainty as to whether they were the same of different decreased, then the contextual factors seemed to play a role in increasing the likelihood of seeing a match. However, this effect was only observed for the context in which extreme physical harm featured in the background story. The study suggests that in cases where there might be some uncertainty as to whether fingerprints match and where the crime is extreme, that matching might be influenced by context.

5.2 Implications for technology

The recording of the environment and collection of objects becomes the main input to a computer system for the CSI. As a photograph is taken or an object placed in an evidence bag, the activity is recorded in terms of date/time and position. Position is supplied either through Global Positioning System (GPS) or through a bespoke positioning system (Cross 2004). The evidence bag itself is tagged with a Radio Frequency Identification (RFID) tag that can be read when it is picked up and data written to (see figure three). Thus, when a CSI picks up an item and places it in an evidence bag, a report is already being written in terms of CSI, date, time, place, type of evidence. The CSI can then add additional information, perhaps in the form of a verbal description to the evidence. Furthermore, by providing at least the crime report, the CSI would have the basic information required to find the scene and begin examination. It is a moot point as to whether any additional incident or activity narrative would be beneficial (or whether this would induce bias in the collection of evidence).



Figure 3. Interacting with objects tagged with RFID, using speech to input descriptions

6. Procedures as resources for action: Distributing crime scene investigation across people, procedures, and technology

Crime scene investigation has evolved in accordance with procedural changes. These changes have been implemented, amongst other reasons, as a consequence of circumstances uncovered during the course of an investigation, as a result of technological advancement, or as a corollary of the increased awareness of contamination issues. A successful outcome to forensic investigation is dependent on the structured and systematic appraisal of the scene, reliant on the practitioner identifying, selecting, recovering and submitting the evidence for testing, in accord with accepted procedures and providing a clear documented record of the examination (Jamieson 2004). To this end, there is a need for the forensic practitioner to be aware of system limitations, and how the product to system amalgamation has to be modified to meet the needs of a socially oriented judicial system (Williams 2004).

While much of Distributed Cognition has concentrated on the use of artefacts as resources for action, Suchman (1987) pointed out that plans and procedures could be treated in the same way as artefacts, i.e., as resources to be interpreted and applied, rather than programs to be followed. This introduces a potential point of tension for crime scene investigation: procedures may be

written with the intention of providing strict guidance on the manner in which evidence is to be collected and crime scenes examined. However, the enormous variation in crime scenes (not to mention pressures placed upon CSIs from different types of investigation) mean that the procedures may not be universally applicable. Thus, a CSI might view procedures as inherently flexible, because of the need to adapt a given procedure to the unique aspects of each crime scene. However, if procedures are written to be followed to the letter and, as such, intended to be programs or rules to be adhered to, then it is possible to question performance when 'off-procedure', which could result in evidence being rejected. Thus, there might be a tension between procedure as program and procedure as resource. Indeed, the role of the CSI has been described as being ambiguous (Wright 2002), and often the direction is torn between the practical demands and official procedural requirements (Hobbs 1988). There are occasions when procedures and investigative parameters stipulated by governing bodies can conflict with the environmental constraints, and operating practicalities of the investigative process.

The point is that it is possible for procedures to function as both prescribed step-by-step instructions and as resources for action. Whenever procedures are presented as step-by-step instructions, there is an attendant possibility that violation might arise, and given the adversarial nature of British Law, this might lead to the authenticity of a particular piece of evidence being called into question, i.e., if it can be shown that the CSI deviated from procedures, then the collection of evidence could be questioned. On the other hand, the procedures might not be suitable to all situations and so require some adaptation (which might be construed as violation if the procedures were written in a very prescriptive manner). A possible solution to the problem would be to present procedures as goals, e.g., ensure recording or avoid contamination, etc. In this way, the account would not be how well the steps were followed but whether goals adhered to and how. However, the end result would be to 'Collect valid evidence from the crime scene', which, in itself requires the CSI to adhere to principles of 'best practice' regarding contamination of evidence, without the need for instructions prescribing the order in which actions are carried out.

This discussion returns to the earlier consideration of narrative versus argument. The aim of the investigation is to provide sufficient evidence, collected in a rigorous and objective manner, to help develop an argument. In this view, crime scene investigation is a process of induction, i.e., from specific evidence to an explanation. The procedures, and the constraints they place on CSIs, can be seen to be designed to follow this inductive process. However, this is in contrast to the fact that much of the investigative process is deductive, i.e., using

hypotheses to determine what information might be beneficial or useful. As we saw in the discussion of objects-as-resources-for-action, a CSI might select objects in terms of their potential to be (or provide) evidence. This decision-making could be seen to be somewhat tangential to the aims of the procedures. If a CSI followed the procedures to the letter, their activity could be readily seen in the light of Bruner's notion of argument, whereas much of the exploration would appear to follow the notion of narrative.

6.1 Implications for technology

To some extent having the means to explain and comment upon activity, such as the audio commentary on a video, could be seen as a useful way of providing narrative within the framework of argument. In this way, the CSI would be able to explain choices made at the scene. While this might satisfy the theoretical concerns raised in the previous section, it does lead to the practical concerns of disclosure raised earlier. If the CSI deliberated over a course of action or piece of evidence, this could be taken to indicate uncertainty — which in Court could be used to indicate a lack of professionalism.

7. Discussion

The suggestion that narratives can be passed through the crime investigation processes suggests a degree of collaboration (see Table 6). As Olson and Olson (2000) point out, technology to support collaboration requires (amongst other aspects) the ability to support common-ground, coupling and to encourage collaboration readiness. Within the Computer-Supported Cooperative Work (CSCW) community, the notion of Common Ground draws upon the work of Clark (1996). This views common ground, between two speakers, as "...the sum of their mutual, common or joint knowledge" (p. 93). In any discourse, it is important for speaker and listener to establish sufficient overlap of knowledge to enable them to refer to a 'common ground'. The speakers do not spend time working out what is common but assume it to be so (unless the assumption is disproved and then some repair is needed). This process could draw upon cultural knowledge to make assumptions about beliefs, actions, language etc. of individuals, e.g., a Caller might attempt to speak in 'police jargon' such as the use of ICAO alphabet for registration plates; or could be personal, in that we share points of perceptual reference, e.g., when the speaker says something like '*that* night', both parties know what is being referred to.

Table 6. Representation of information in the Crime Scene Investigation System

	State: environment	State: object	State: perpetrator	State: victim
Incident	Verbal (caller) Textual (999 Ops)	Verbal (caller) Textual (999 Ops, caller)		Verbal (caller) Textual (999 Ops)
Activity	Verbal (caller) Textual (999 Ops, Attending officer)	Verbal (caller) Textual (999 Ops, Attending officer)		
Crime	Textual (999 Ops, Attending officer)	Textual (999 Ops, Attending officer)		Textual (999 Ops, Attending officer)
CSI	Graphical (CSI) Photographic (CSI) Textual (CSI) Numerical (CSI)	Graphical (CSI) Photographic (CSI) Textual (CSI) Numerical (CSI)	Graphical (CSI) Photographic (CSI) Textual (CSI) Numerical (CSI)	Graphical (CSI) Photographic (CSI) Textual (CSI) Numerical (CSI)
Forensic	Graphical (Forensic) Photographic (Forensic) Textual (Forensic) Numerical (Forensic)	Graphical (Forensic) Photographic (Forensic) Textual (Forensic) Numerical (Forensic)	Graphical (Forensic) Photographic (Forensic) Textual (Forensic) Numerical (Forensic)	Graphical (Forensic) Photographic (Forensic) Textual (Forensic) Numerical (Forensic)
Report	Textual (Attending officer, CSI, Forensic)	Textual (Attending officer, CSI, Forensic)	Textual (Attending officer, CSI, Forensic)	Textual (Attending officer, CSI, Forensic)
Case	Verbal (caller, Barrister, attending officer, CSI, forensic)	Verbal (caller, Barrister, attending officer, CSI, forensic)	Verbal (caller, Barrister, attending officer, CSI, forensic)	Verbal (caller, Barrister, attending officer, CSI, forensic)
Accused	Textual (accused, witnesses) Verbal (accused, witnesses)	Textual (accused, witnesses) Verbal (accused, witnesses)	Textual (accused, witnesses) Verbal (accused, witnesses)	Textual (accused, witnesses) Verbal (accused, witnesses)

From this view, a challenge CSCW is to provide a means by which people can negotiate (or otherwise work with) ‘common ground’. Unfortunately, the notion of common-ground is somewhat problematic when applied to crime

scene investigation: on the one hand, it implies a mutual understanding of all relevant material (which is likely to be desirable); but on the other hand, it implies a common view of the situation (which is likely to be undesirable in that it suggests a degree of biased interpretation). The process of collecting evidence is supposed to be performed independently, so that when all the evidence is gathered together, it can be interpreted objectively. Furthermore, the very nature of crime scene investigation means that the entire process is geared towards constructing 'common ground' (or a case that can be tried in Court). The key issue would appear to be how best to define the elements which are essential to share.

The technologies developed during this project aim at supporting collaboration throughout the CSI process. At the scene itself, collection of evidence is used to automatically log activity and record exhibit details. This automatic log is made available to colleagues, to support discourse related to ongoing activity, but can also be re-used by investigators later, i.e., by having all information stamped with location data. We view such developments as the logical extension of the increasing digitisation of CSI and the increasing communications bandwidth offered by TETRA (and similar broad-band radio systems). By considering the narrative, collaboration and resources-for-action, we believe that it is possible to engage in theoretically-driven, user-centred design of future CSI technology.

Notes

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1. The process outlined in this section, and considered throughout the paper, is taken from UK practice. There may well be differences in some aspects across different countries and we are not claiming superiority for UK practice, merely acknowledging this is the source of information used in our work.

2. In England and Wales, all cases start off at a magistrate's court, and the magistrate takes the decision as to whether a 'higher' court is necessary, according to the offence). It is also possible for the accused to opt to have their case tried in a higher court.

3. **The evidential test** — the CPS must be satisfied that there is enough evidence to provide a "realistic prospect of conviction". If the evidence is not strong, the CPS asks: Can the evidence be used in court? Is the evidence reliable?; **The public interest test** — There are instances when looking at the public interest will lead to a decision not to prosecute.

4. As far as possible the format and content of the tables in this paper are drawn from incidents handled by a UK Constabulary. Under the constraints and restrictions of the Data Protection Act, it is not possible to exactly reproduce the material and so modifications have been made. Items in italics have been altered, but do not substantively alter the content of the table for the purposes of the discussion.
5. Section 3 (1) of the Main Provisions of Criminal Procedure and Investigations Act, 1996 clearly states that, "*The prosecutor must — (a) disclose to the accused any prosecution material which has not previously been disclosed to the accused and which in the prosecutor's opinion might undermine the case for the prosecution against the accused, or (b) give to the accused a written statement that there is no material of a description mentioned in paragraph (a)*".

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