Crime Scene Science: Future research directions

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Goals of work

- Muse about purpose of crime scene examination
- Examine the forces shaping forensic science work
- Explore rationale for current research
- Examine current paradigm
- Suggest benefit of an additional (not different) direction

Goals of work

- Suggest modification to prevailing paradigm –add the origin of evidence
- Explore research into origin of evidence
- Propose the “Crime scene theater”
- Propose a use for the research – prediction that assists searching
- Detail how the crime scene examination might be different

A crime is committed

- An action or omission that constitutes an offense that may be prosecuted by the state and is punishable by law
- The state finds the action unreasonable and wants to know whether someone should be prosecuted and punished for it
- An investigation ensues that attempts to determine whether all of the elements that constitute the crime are present
  - The investigation includes identifying the person responsible

A crime is committed

- The investigation might include the use of science to identify elements and persons
- The goal of the investigation is to identify evidence relevant to an offense and bring that to a prosecuting officer
  - Not all information uncovered is evidence adduced at trial
- The role of science at the scene is to assist in finding physical evidence relevant to the criminal act
  - Finding objects related to the event in question
  - Excluding objects with no relationship to the event

A brief diversion:
What is the purpose of a forensic science examination?

- Find out some legally important and useful information about a violent/criminal event that has occurred in the past
  - Forensic science attempts to reconstruct the past
  - Generate *expectation* of what we would see today if event had occurred as proposed
  - Requires explicit hypothesis formulation before beginning an exam, based on prior experience, scientific background knowledge, preliminary observations, and logic

A common pursuit: crime scene reconstruction

- Using all evidence to infer the
  - The relative time of each of many contacts
  - The absolute time of each contact
  - The relationship of the discovered evidence to the crime alleged

Forces affecting direction of forensic science research

- While labs originally tapped for investigative leads, in the early to mid 70's the drug avalanche forced a re-evaluation of priorities and shifting of resources
- Labs became overwhelmed with work; no increase in resources
- Analysis of large quantities of solid dose drugs and toxicology analyses
- ***Only cases with named suspects*** were accepted into the lab for other exams (FP, TM/FA, biology, trace)

Forces affecting direction of forensic science research

- Forensic science role became primarily that of assisting in prosecution by examining evidence obviously linked to the crime
- At the end of two decades of these forces, a paradigm emerged and became prevalent: a hierarchy of propositions
  - Source – Who or what left this material at the scene?
  - Activity – Were these two objects in contact with one another?
  - Event – Who engaged in an illegal act?

On the legal side

- Eyewitness accounts were found to be wanting
- More reliance on science by law and law enforcement
- Courts developed criteria for admissibility of scientific evidence
  - Daubert, et.al.

Result of all forces

- Laboratories turned to analyzing evidence in pursuit of legal prosecution…
- …and much less on evidence discovery and investigative leads
- There was lots of evidence to examine
  - And too few analysts to examine it
- Few asked whether we were collecting the right stuff, or at least all of the right stuff

How did that affect research?

- Research currently geared towards validation studies designed to meet court admissibility requirements
  - Admissibility requirements are legal criteria + precedent with a little science thrown in
  - Goal is a safe conviction
  - In other words, the law wants/requires science to participate in safe convictions
    - Or at least not contribute to unsafe convictions
- And science has, wittingly or not, acceded to those requirements

How did that affect research?

- Lots of research on analyzing evidence
- But little to nothing about the variety and quantity of physical evidence produced during different kinds of violent events
  - Beating with blunt objects
  - Stabbing
  - Strangulation, manual and ligature
  - Shooting
- BSP has done some of this
  - e.g., what pattern results from impact, as opposed to transfer?

Is there some research on crime scene?

- Reasonable amount on processing the scene and depicting the scene
  - One example: A Solution for Crime Scene Reconstruction using Time-of-Flight Cameras
  - https://arxiv.org/pdf/1708.02033.pdf (August 2017)
  - Less precise than environmental laser scanner
  - More practical and portable
  - Hardware cheaper

A Solution for Crime Scene Reconstruction using Time-of-Flight Cameras

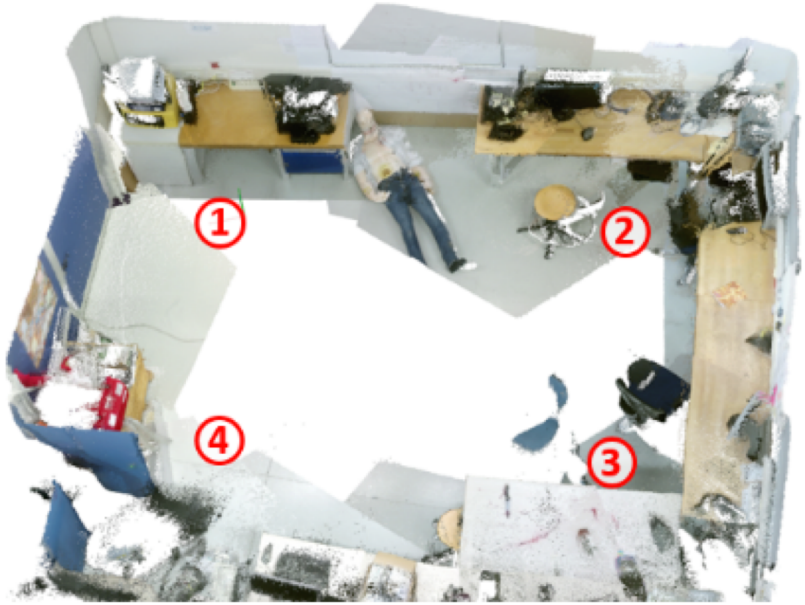

Figure 4. Reconstruction of surrounding environment.

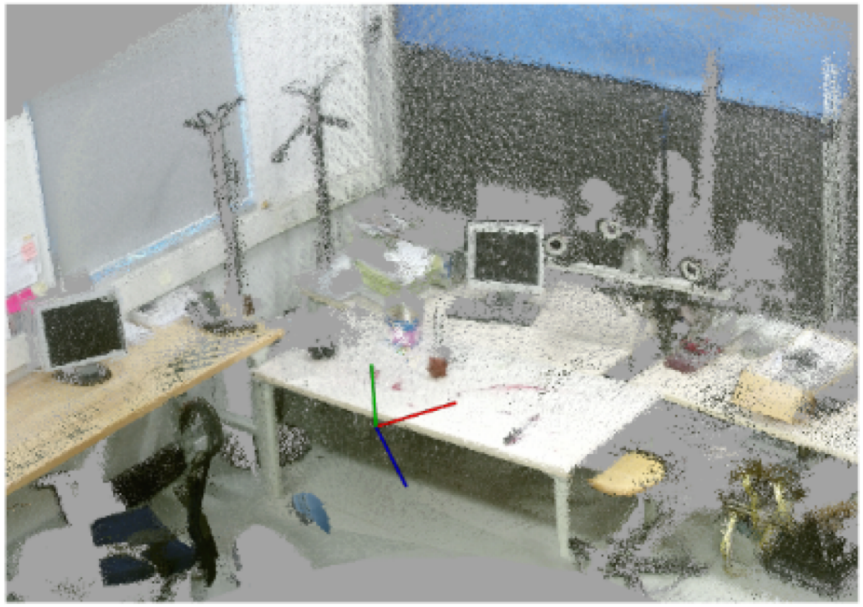

Figure 5. Focus on corner 3 part of the reconstruction.

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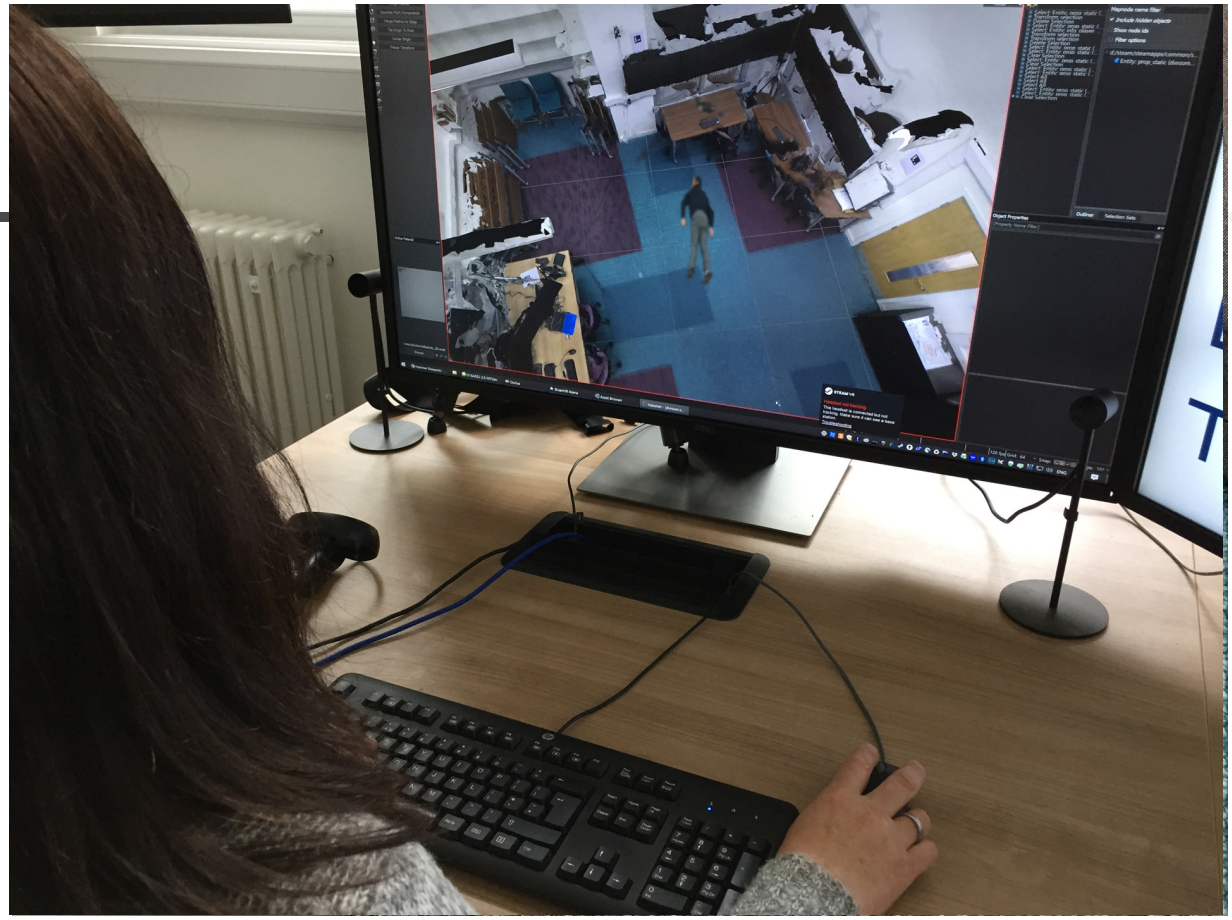
Augmented Reality for crime scene documentation

- Roy Mudie and colleagues at University of Dundee
- EAFS 2018
- Ability to precisely locate evidence and update over hours, days or months as more information gathered



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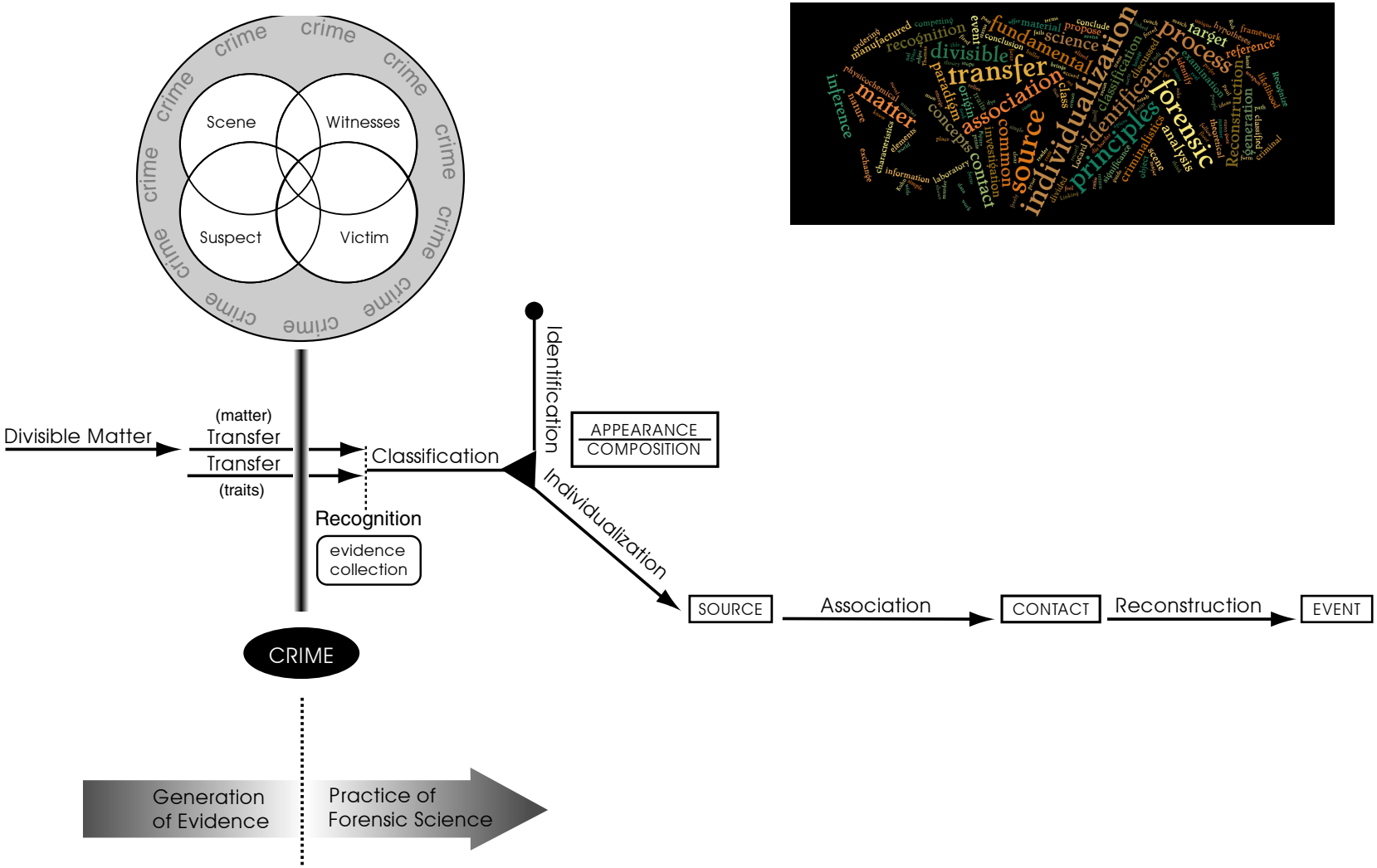
Is there more to consider?

- Little research on discovering evidence
- A more expansive paradigm would assist in expanding the vision of research needed throughout forensic science
- A paradigm that includes a consideration of the origin of evidence would assist this effort
  - Forensic science paradigm
  - Shannon's information theory


crime
Scene
Witnesses
Suspect
Victim
Divisible Matter
(matter)
Transfer
Transfer
(traits)
Classification
Recognition
evidence collection
Identification
APPEARANCE
COMPOSITION
Individualization
SOURCE
Association
CONTACT
Reconstruction
EVENT
CRIME
Generation of Evidence
Practice of Forensic Science

Claude Shannon: Transmission of Information

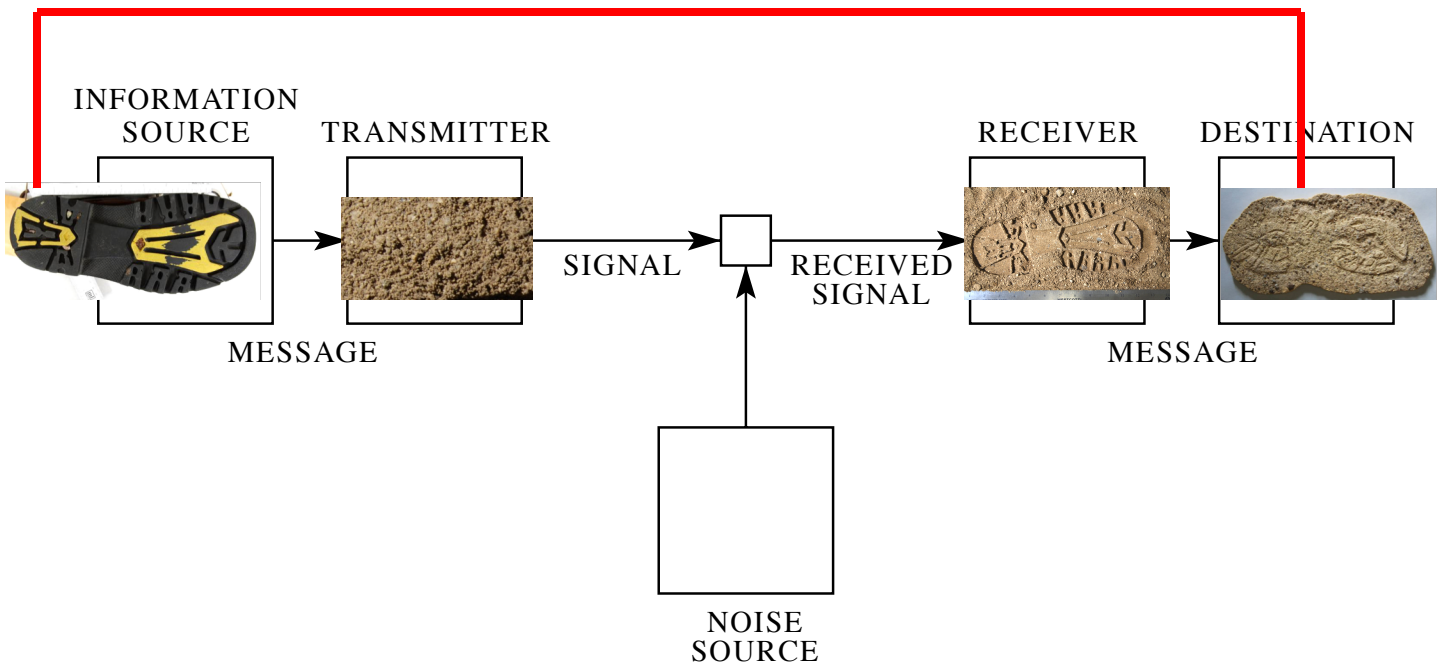


Fig. 1 — Schematic diagram of a general communication system.

Suggestion: Research focused on evidence creation

- Most stand in the crime scene and look around and ahead: what do I see that will help me understand what happened?
- Look in the opposite direction of the crime scene, back to the crime event, and ask:

What would have been created during the event?

What expectation should I have if X happened?

What expectation should I have if Y happened

In practice:

Observation:

Multiple blunt force injuries to face

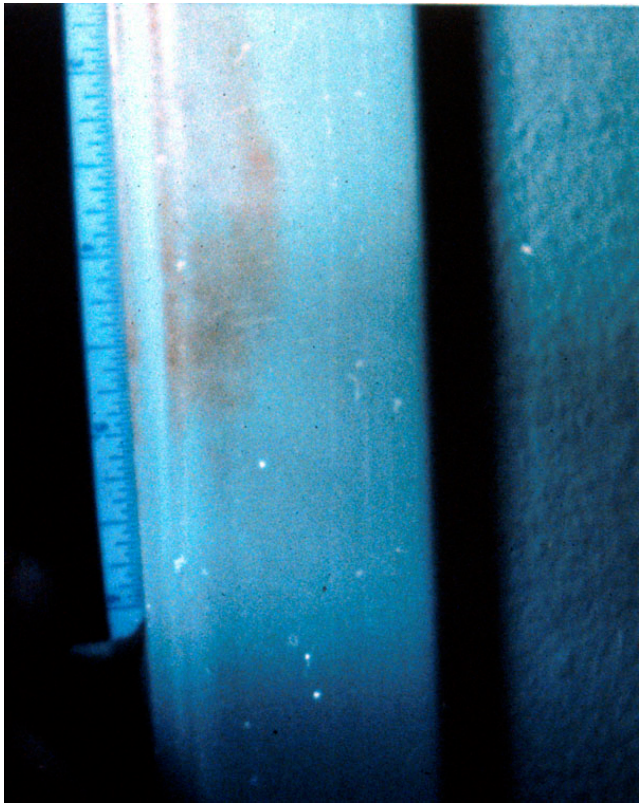
- Hypothesis:
  - Bludgeoned to death
- Prediction:
  - Numerous bloodstain patterns;
  - Lots of blood
- Search for blood

Obvious Example…

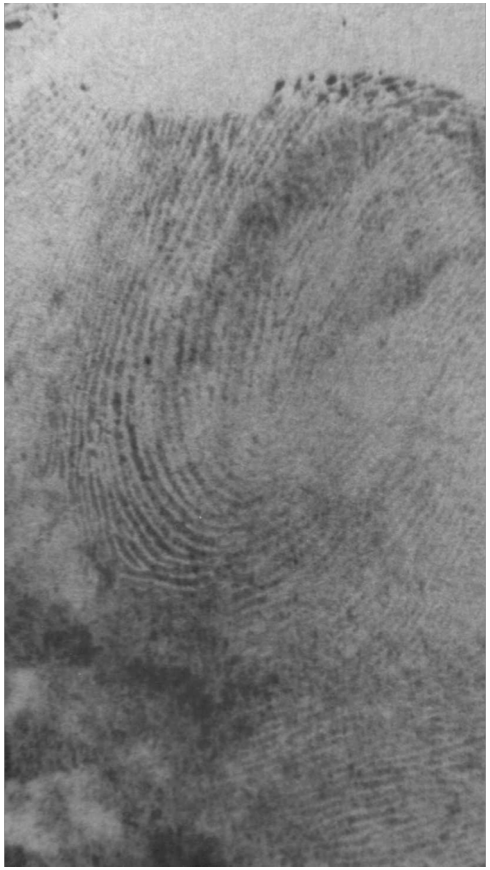
- Is there other evidence for which we should search?
  - Only some idea of the range of evidence created during a prototypical bludgeoning will answer that question (in a scientific manner)
- Do we also expect the instrument to have struck one of the walls?
  - How often?

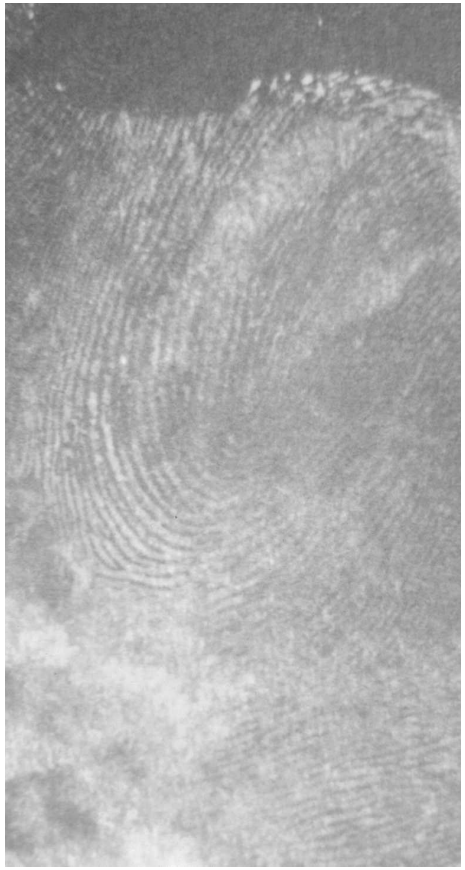
- Should some trace of the wall be found on the instrument?
  - How long would such a trace be expected to persist?
  - What factors would cause it to be lost?
  - What factors would cause it to degrade (give trait values that differ from its original state)?

Not so obvious…



- Prediction:
  - That amount of bloodshed results in bloody assailant
- Search:
  - For transfer from assailant
- Find:
  - Bloody dermal ridge print
- Predict:
  - Bloody prints are frequently reverse prints





- This perspective requires us to perform research that predicts what evidence would be found
- It would be useful to conduct research on what physical evidence is produced during violent criminal events: the origin of physical evidence
- Use in practice:
  - From an initial observation(s) propose a hypothesis for the event
  - Inquire of the intelligence database: what physical evidence is created when this event occurs?

Origin of evidence

- Interested in the dynamics of what and how physical evidence is produced and dispersed during an act of violence
- The results of such research would be not only an understanding of what could be produced, and where it might be deposited
  - But can ultimately be modeled for how much of any evidence could be produced
  - How long such evidence would persist, and what factors lead to its absence
  - What changes such evidence would undergo, and what factors would hasten and mitigate such changes

- Research into the decay or degradation of evidence would be an integral part of such research
  - How long does each item last?
  - What are the factors producing degradation?
  - How much of the individuality of a trace is lost over time, and how is the process delayed or accelerated?

When research used properly…

- Promotes multiple hypothesis formation at the scene
- Resulting in the search for a wide variety of types of evidence: science provides a predictive element to the scene processing
- More relevant evidence collected at the scene narrows the later inferences that are reasonable, both in terms of source and activity.

When combined with lab analysis

- A degree of uncertainty can be expressed without regard for admissibility issues:
  - A degree of belief that equals 10%, for example, is a perfectly reasonable investigative lead, for the detective can incorporate such uncertainty into his evaluation of the value of the information in pursuing a person or a scenario.
  - There's nothing inherently unreliable with a 16% chance that the person leaving this biological trace has blue eyes
- It's actually better than most of what is communicated in laboratory reports
- More science, less law, is used in such a process

Crime Scene Theater

- A facility equipped with
  - High speed still and video cameras
  - Sensors capable of detecting a range of applied forces
  - Kinetic energy generators - Instruments capable of delivering reproducible force for the study of violent acts
  - Sound sensors capable of measuring the amount of sound generated by a wide range of causes from bumps to gunshots
  - Mobile walls to produce rooms of a variety of sizes

How might that be accomplished?

- Crime Scene Theater
  - Violent acts repeated
  - Recorded as for computer game development
  - Math modeling + computer simulation/gaming
  - It is very inter-disciplinary

Crime Scene Theater

- Multi-disciplinary, potentially involving faculty and students from
  - Chemistry
  - Physics
  - Mathematics and statistics
  - Computer science (simulations and gaming)
  - Theater and drama

Goal of research into the origin of evidence

- Produce a “horizon of expectations” for any hypothesized event
- This can assist in directing attention (not focusing to the exclusion of other evidence) to searching for the expected evidence
- The more such evidence is found, the more likely is the hypothesis to be approximately correct.

Goal of research into the origin of evidence

- The expectations would include
  - Production (through knowledge of manufacture and division)
  - Dispersion (through transfer/Locard)
  - Persistence
  - Degradation

- The validation of such a model should have a different goal than validation of methods for court admissibility
- Court decisions are made with a set of legal rules and criteria involved
- Goal of techniques and methods for examining a crime scene are to understand what happened and who was involved
  - Reliable investigative leads are produced

Not all leads are correct

- Like eyewitness ID's, or circumstantial evidence, they may lead in the wrong direction
- Training on use is vital
- Understanding inference and balance of probability a must for detectives to properly use the evidence found through prediction as leads

This model could fail

- This is the closest thing to basic science research that one could conceive for forensic science
- At the end of 5 or 10 years, it may all come to naught
- But if it succeeded, or parts of it succeeded, it would change the way that crime scenes are processed.

Summary of Research

- Basic research into the finding of relevant legal physical evidence
  - How generated during real acts of violence
  - Modeling or simulating acts of violence
  - How long does physical evidence persist/what is the decay rate of various kinds of physical evidence
  - What time constraints are present
  - Best practices for evidence discovery and collection
  - Generation of probabilistic models of reconstruction based on either repetitive testing or boot-strap models