Science in Bloodstain Pattern Analysis

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Science is the supporting structure of the field of bloodstain pattern analysis. If it were not, testimony to this important form of evidence would be inadmissible. Nevertheless, the extent to which the analysis of bloodstain patterns is permeated by scientific thought and principles may be overlooked at times. In this article, I will point out several areas of the field that should meet high scientific standards if they are to play a constructive role in the legal system. These areas include:

1. The recognition of bloodstain patterns
2. The classification of bloodstain patterns
3. The assignment of cause to bloodstain patterns
4. The development of crime-scene reconstructions
5. The design and interpretation of demonstrations to be used in court.

In response to the U. S. Supreme Court's 1993 Daubert decision[1], practitioners of many disciplines in forensic science have sought to show that their fields of expertise meet the criteria for admissibility delineated in Daubert. Because of its specific subject matter, the Daubert decision dealt with "scientific knowledge." Six years later, in *Kumho Tire Co., Ltd., et al. v. Carmichael et al.*[2], the court explicitly extended its support for the application of the Daubert factors ("criteria" below) to expert testimony by "...other experts who are not scientists." Thus, under Daubert both scientists and non-scientists can testify to technical matters so long as methods employed in their work are scientifically valid and meet, at least in part[3], the following criteria: 1) the method has been or can be tested, 2) it has been peer reviewed or published, 3) it has a known or determinable rate of error, and standards exist for its use and 4) it has attracted widespread acceptance in a relevant field of activity. The court also emphasized that these factors apply to principles and methods rather than to conclusions.

What are the principles and methods underlying the analysis of bloodstain patterns found at crime scenes or on items of evidence? There are two classes of principles and methods used in bloodstain pattern analysis: *physical* and *intellectual*. For example, the laws of physics are the principles underlying the methods used to explain trajectories of blood drops and to estimate areas of origin of spattered blood. The corresponding methods in these determinations are various means of making measurements and calculations. Such methods have been thoroughly tested, have readily determinable errors, have been included in peer-reviewed publications and are widely accepted. Thus, if it were to be considered *in vacuo*, testimony by a qualified expert on determining trajectories or areas of origin would likely not succumb to opposition based on Daubert.

Principles and methods also govern the recognition and classification of patterns[4] and the assignment of general or specific causes to patterns. The first step in bloodstain pattern analysis is recognition that a pattern is present. Once a pattern has been recognized, it may be classified as to type. Recognition involves making an adequate examination of a well preserved and documented

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[1] *Daubert, et al. v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993).

[2] 526 U.S. 137 (1999).

[3] The court noted that the four factors do not constitute a checklist such that all criteria must be met.

[4] It is important to note that many bloodstain patterns at crime scenes are of complex origin and may not fit neatly into an established class. In this article, the terms "stain" and "pattern" are used with the understanding that greater complexity may be involved.

crime scene, evidence from a crime scene or corresponding photographs. The methods used to examine crime scenes or evidence are visual observation with the unaided eye, visual examination with the aided eye including illumination with light of various energies, microscopy, chemical testing and chemical enhancement. Such procedures are based on established physical principles and they readily comply with the Daubert criteria.

The fundamental tool in classifying patterns is visual observation. This approach is generally similar to practices in other scientific disciplines, such as biology and medicine, among others. For example, in the field, ecologists classify species by their appearance. Similarly, pathologists may classify cells as malignant or normal by microscopic examination of their morphology. Forensic pathologists classify wounds by their appearance.

In bloodstain pattern analysis, however, classification of a stain or pattern is often tantamount to assigning cause to the stain. Names of stain or pattern types such as "impact spatter," "compression transfer," "expirated blood," "cast-off," "spurt" and "blood dripping into blood" attribute *cause* at the same time they describe *appearance*. For example, if an expert classifies a stain on the wall as "impact spatter," the inference that a blow was delivered to a blood source in proximity to the wall follows immediately from the classification. This can be problematic because it introduces cause before a full set of observations has been made. If bloodstain pattern analysts were to adopt cause-free stain nomenclature, it would diminish the possibility of such pre-analysis assignment of cause. It is, however, necessary to deal properly with causality because testimony to bloodstain patterns would not be relevant evidence if it did not deal with it. It is not helpful to juries to know the name of a stain; they need expert opinion on what could have caused the stain, what could not have caused it, and how various aspects of the crime scene provide context for the bloodstain patterns that we use in reconstruction.

The assignment of cause goes beyond documenting appearances; it is inherently an element of reconstruction. Since the role of science in reconstruction is a theme of this essay, reconstruction should be defined: a *"reconstruction" is composed one or more inferences made about activities surrounding the commission of a crime; reconstruction is a scientific process* and thus must concern only physical matters and must be based on and supported by the results of examining physical evidence. As more scientific evidence is amassed, the process of integrating and interpreting it and incorporating it into a reconstruction poses a high-order scientific challenge.

Making inferences is an intellectual principle in all of science; its use in bloodstain pattern analysis ought to meet Daubert standards. Thus, the problem that needs to be addressed is how to ensure the reliability of inferences. Limiting the input (physical evidence) and output (physically supported inferences) of reconstruction to physical parameters and observations is the key to reliability because it focuses on the objects of science.

Every scientist who has made statements to colleagues that went beyond what the data specifically allowed is likely to have experienced the knee-jerk intolerance that scientists have for such remarks unless they are clearly qualified as speculation or as hypotheses yet to be tested. Scientists know from their training and experience not to say more to other scientists than can be supported by physical evidence. In the area of bloodstain pattern analysis, a scientific principle determining the reliability of inferences might be, *our inferences are most reliable if we limit them strictly to physical matters, and do so in the most conservative fashion possible*. For pedagogical purposes, here are two fictitious examples of testimony[5]:

[5] Any similarity to the testimony of crime scene analysts, living or deceased is purely coincidental.

Based on the appearance of this pattern, the sizes and directionality of its constituent droplets, my determination of an approximate area of origin of the spatter, on the report of the medical examiner and on the photographic documentation of the scene, including images of a bloody baseball bat with hair fragments on it located on the floor approximately 3 feet from the body, it is my opinion that the pattern arose by impact of the bat on the head of the victim while it was approximately 2 feet from the wall at the center of the pattern and 18 inches above the floor. It is possible, though, that some elements of the pattern arose from cast-off from the bat and from blood expirated from the airway of the victim.

2. I have been present at more than 300 crime scenes. Based on my experience, it is my expert opinion that crimes of extraordinary violence such as this one are perpetrated by psychotic individuals. There is a large soak-transfer stain on the back of the victim's shirt. There is cast-off on the ceiling and on the east and west walls. Because all nine of the stab wounds in the victim's back were located within a relatively small area, I believe it likely that at least two people, possibly more, committed this crime, and that the victim was held by one and stabbed by another. People who plan murders such as this generally enter by some furtive route, such as a window. Most often, they take a souvenir from the scene to relive the exhilaration of their crime. We were unable to find the victim's underpants. The rear door was open; the perpetrators evidently left by that route.

The first of these examples is science; the second is lay opinion sprinkled with a few technical terms. You may ask yourselves what kinds of observations could convert the second example to science. I think your close, critical examination of this example could be instructive. It has become dogma that bloodstain pattern analysts should include demonstrations in their testimony whenever possible. I think this is a good idea, and I do it when I testify. Here I treat the matters of how such demonstrations are designed, why they might be designed and what one can conclude from them. I introduce the topic by comparing a demonstration to an experiment.

Ideally, scientists perform experiments in order to determine the effect of a single variable on the behavior of a system. All other variables must be held constant to ensure that the results can be attributed to changes in the variable of interest. An example of an experiment often carried out in bloodstain pattern analysis training is to vary the height from which a blood drop is allowed to fall to the floor. The height is the variable of interest. The size and shape of the resulting stains are measured and recorded. After reproducing the experiment a few times and averaging the data, the experimenter reviews and interprets the results. Perhaps the result will be that between heights of 6 inches and 24 inches the stain becomes reproducibly larger. At a certain height the stain might reproducibly show changes in its shape, particularly at the edges. Needless to say, if more than one parameter were changed, results could not be interpreted. For example, if the properties of the target's surface varied at each change of height-of-fall, no statement could be made about the effect of either variable (height and surface) on the shape of the stain. Many demonstrations are not experiments. Consequently, findings in demonstrations may not allow the kinds of conclusions that might be drawn from experiments.

In my presentation at the 2005 Annual Training Conference in Santa Barbara, California, I showed a slide of a demonstration in which I hit a small pool of blood deposited on a horizontal surface with the palm of my hand. The pool was located about six inches from a vertical target, which was a piece of butcher paper. The resulting pattern resembled in general features a pattern on a wall adjacent to the body of a man who, according to the medical examiner, had been murdered by repeated blows to

the head with a blunt object. The purpose of this demonstration was to show that impact on pooled blood could generate a pattern resembling that photographed at the crime scene. It is clear, however, that other mechanisms, singly or in combination, could have produced the crime-scene pattern. One example might be expirated blood.

The fact that I was able to produce a pattern by impact that resembled the crime-scene pattern in no way rules out the possibility that expirated blood was present, possibly as a major contributor to portions of the questioned stain. The point is that such a demonstration is of very limited scientific value. Based on observations of the demonstration pattern, one can only make a statement of the type: *some features of patterns resulting from impact on pooled blood are present in the questioned pattern.*

The theme of this article is that science plays a greater role in our field than just underlying obvious physical phenomena. In my view, the most significant role of science in any technical discipline to which testimony may be given is to ensure that statements made by experts are bounded by established rules of scientific practice. The following list summarizes what I look for in my own work and testimony:

- Limit hypotheses and conclusions to physical entities
  Do not falsely eliminate competing hypotheses by using phrases such as:

  "…the killer would have…"
  "…the killer would not have…"
  "…my demonstration shows that it could not have been…" (if it doesn't)

  Pare your statements down to the minimum needed to communicate your firmest opinions so that they are scientifically sound

I invite the readers to contact me for any further discussion of these topics.

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