Latent Print Examination and Human Factors: Improving the Practice through a Systems Approach


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In Memoriam
This report is dedicated to the memory of Danny Greathouse, a valued contributor to this study and a friend who will be missed.
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Introduction

Fingerprints have provided a valuable method of personal identification in forensic science and criminal investigations for more than 100 years. Fingerprints left at crime scenes generally are latent prints—unintentional reproductions of the arrangement of ridges on the skin made by the transfer of materials (such as amino acids, proteins, polypeptides, and salts) to a surface. Palms and the soles of feet also have friction ridge skin that can leave latent prints. The examination of a latent print consists of a series of steps involving a comparison of the latent print to a known (or exemplar) print. Courts have accepted latent print evidence for the past century. However, several high-profile cases in the United States and abroad have highlighted the fact that human errors can occur, and litigation and expressions of concern over the evidentiary reliability of latent print examinations and other forensic identification procedures has increased in the last decade.

“Human factors” issues can arise in any experience- and judgment-based analytical process such as latent print examination. Inadequate training, extraneous knowledge about the suspects in the case or other matters, poor judgment, health problems, limitations of vision, complex technology, and stress are but a few factors that can contribute to errors. A lack of standards or quality control, poor management, insufficient resources, and substandard working conditions constitute other potentially contributing factors.

In addition to reaching correct conclusions in the matching process, latent print examiners are expected to produce records of the examination and, in some cases, to present their conclusions and the reasoning behind them in the courtroom. Human factors issues related to the documentation and communication of an examiner’s work and findings therefore merit attention as well.

The study of human factors focuses on the interaction between humans and products, decisions, procedures, workspaces, and the overall environment encountered at work and in daily living. Human factors analysis can advance our understanding of the nature of errors in complex work settings. Most preventable, adverse events are not just the result of isolated or idiosyncratic behavior but are in part caused by systemic factors. The forensic science community can benefit from the application of human factors research to enhance quality and productivity in friction...
ridge examinations and to reduce the likelihood and consequences of human error at various stages in the interpretation of evidence.

To further this effort, the National Institute of Justice (NIJ) Office of Investigative and Forensic Sciences (OFIS) within the U.S. Department of Justice and the National Institute of Standards and Technology’s (NIST’s) Law Enforcement Standards Office (OLES) sponsored the work of this expert panel to examine human factors in latent print analysis and to develop recommendations to reduce the risk of error and improve the practice of latent print analysis.

1. The Expert Working Group on Human Factors in Latent Print Analysis

The Expert Working Group on Human Factors in Latent Print Analysis was convened in December 2008 and charged with conducting a scientific assessment of the effects of human factors on forensic latent print analysis. A scientific assessment, as defined by the Office of Management and Budget, “is an evaluation of a body of scientific or technical knowledge which typically synthesizes multiple factual inputs, data, models, and assumptions, and/or applies best professional judgment to bridge uncertainties in the available information.”

The Working Group was charged with:

- Developing an understanding of the role of human factors and their contributions to errors in latent print analysis through an evidence-based review of literature, case studies, and previous analyses;
- Evaluating approaches to reducing errors in terms of their efficacy, appropriateness in different settings and circumstances, cost, scientific basis, feasibility, institutional barriers to implementation, associated risks, and the quality of evidence supporting the approach;
- Providing guidance to the latent print analysis community on the practical, scientific, and policy outcomes of its work through peer-reviewed publications, presentations at conferences and meetings, and government-sponsored publications;
- Providing guidance to policy-makers and government agencies in promoting a national agenda for error reduction in latent print analysis;
- Attempting to develop credible estimates of the incidence, severity, and costs of errors; and
- Making recommendations for future research.

Working Group members were selected because of their expertise in the forensic sciences or another relevant field and the ability to balance scientific rigor with practical and regulatory constraints. The Working Group consisted of experts from forensic disciplines, statisticians, psychologists, engineers, other scientific experts, legal scholars, and representatives of professional organizations.

The Working Group met 9 times over the course of 2 1/2 years and heard presentations from experts in human factors, vision science, laboratory design, latent print identification, and interpretation in forensic science. Each chapter in this report was developed by a subgroup of the

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Working Group, reviewed by the entire Working Group, edited by a committee within the group, and reviewed again by a set of independent experts. The report was developed through a consensus process in which each Working Group member had an opportunity to influence the recommendations and writing. Despite the diversity of backgrounds and views, the Working Group was able to reach substantial agreement on many important issues, not limited to the formal recommendations. On some matters, however, an irreducible range of opinions remained, and particular chapters indicate those issues.

2. About the Sponsors

NIJ is the research, development, and evaluation agency of the U.S. Department of Justice and is dedicated to researching crime control and justice issues. NIJ provides objective, independent, evidence-based knowledge and tools to meet the challenges of crime and justice. The Office of Investigative and Forensic Sciences (OIFS) is the federal government’s lead agency for forensic science research and development as well as for the administration of programs that provide direct support to crime laboratories and law enforcement agencies to increase their capacity to process high-volume cases, to provide needed training in new technologies, and to provide support to reduce backlogs. Forensic science program areas include Research and Development in Basic and Applied Forensic Sciences, Coverdell Forensic Science Improvement Grants, DNA Backlog Reduction, Solving Cold Cases with DNA, Postconviction DNA Testing Assistance, National Missing and Unidentified Persons System (NamUs), and Forensic Science Training Development and Delivery.

NIST’s mission is to advance measurement science, standards, and technology. It accomplishes these actions for the forensic science community through the OLES Forensic Science Program. The OLES Forensic Science Program directs research efforts to develop performance standards, measurement tools, operating procedures, guidelines, and reports that will advance the field of forensic science. OLES also serves the broader public safety community through the promulgation of standards in the areas of protective systems; detection, enforcement, and inspection technologies; public safety communication; and counterterrorism and response technologies.

3. Organization of This Report

Chapter 1 provides an overview of the Analysis, Comparison, Evaluation, and Verification (ACE-V) process for the examination of latent prints. The chapter also explains certain terminology used throughout the report.

Chapter 2 outlines the general ideas behind human factors and organizational theory. It also addresses the nature of errors in latent print analysis, the reasons for identifying them or measuring their prevalence, and possible ways to estimate accuracy and error rates.

Chapter 3 describes, defines, and clarifies the interpretative stages of latent print comparisons. In addition, it describes the current state of knowledge, based upon published research, and discusses what this research suggests about potential concerns and pitfalls in the interpretive process.
Chapter 4 surveys new and forthcoming methods, technologies, and techniques. It examines research needs and ways to improve existing technologies for recording and storing exemplars, for utilizing automated searches to locate exemplars for further comparison, and for conducting latent print examinations.

Chapter 5 addresses written reports that summarize and document the results of friction skin impression examinations. Best practices in report writing and documentation increase the likelihood that the evidence is scientifically accurate and will be used appropriately in the administration of criminal justice. The chapter describes the purposes and value of reporting and documenting examinations and makes suggestions regarding the content of these materials. Appendices provide examples of sample reports.

Chapter 6 discusses trial and pretrial communications from the expert to lawyers, judges, and juries. It reviews the more important legal rules and principles that apply to these activities and surveys the types of testimony that might be provided at trial.

Chapter 7 focuses on the conditions under which latent print work is performed that can affect quality in the latent print examination process. It considers issues such as scheduling, lighting, workstations, interruptions, and workplace design.

Chapter 8 reviews the current status of education and training for latent print examiners, requirements and evaluation criteria, and curricula. It makes recommendations for training and educational programs to improve quality and accuracy in latent print analysis and reporting.

Chapter 9 focuses on the role of management in developing and maintaining the system for producing high-quality results. It reviews the components of a quality organization focused on latent print analysis. These include management, personnel, accreditation, certification, proficiency testing, and a systems approach to error identification and mitigation. It recommends actions that managers and the latent print community should take to create or maintain quality latent print units.

Chapter 10 summarizes the most important parts of the preceding chapters. It draws the recommendations from Chapters 3 through 9 into categories that may be helpful for latent print examiners, managers, research funding agencies, researchers, policymakers, and jurists. An appendix lists all formal recommendations in order of their appearance in this report.

Although this report explicitly addresses only the procedures for performing a latent fingerprint examination and communicating the results, much of the analysis and many of the recommendations are applicable to other forensic science disciplines. Issues of cognitive bias, standardization of procedures, documentation of examinations, working conditions, error detection and correction, and accuracy in testimony—among many others—cut across the forensic sciences. By identifying and managing the human factors issues relevant to latent print analysis, the latent print community not only can enhance the quality and accuracy of its contributions to the justice system but also can set an example for other forensic disciplines. The Working Group hopes that this report will assist in this effort.
4. Contributors to This Report

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The Working Group relied upon the contributions of many individuals. The opinions presented over the course of the Working Group’s deliberation reflect personal experiences and research. The views in this report do not express the official positions of the institutions with which the members are affiliated.

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Chapter 1: The Latent Print Examination Process and Terminology

Introduction

The conventional procedure for associating impressions of friction ridge skin by a latent print examiner involves four phases known as Analysis, Comparison, Evaluation, and Verification (ACE-V). This chapter describes the ACE-V process, notes some of its limitations, identifies areas where human factors should be considered, and defines certain terms used throughout this report.

Box 1.1: Terminology

*ACE-V:* An acronym for Analysis, Comparison, Evaluation, and Verification. The ACE-V process is described in section 1.1.

*Bias* and *error:* Defined and discussed in section 1.2.

*Exemplar or known prints:* Prints deliberately collected from an individual, usually fingerprints. Exemplar prints can be collected electronically or by using ink on paper cards. Exemplars may be called *ten-prints* when impressions of all ten fingers are taken. Exemplar prints collected during criminal arrests normally include one rolled (from one side of the nail to the other) print of each finger pad and a plain or slap impression of each finger.

*Focal point:* A small region containing distinguishing features within a print.

*Forensic service provider:* A laboratory or unit that examines physical evidence in criminal matters and provides testimony and reports about the examination findings. In this report, the term is used interchangeably with agency.

*Latent print:* Unintentional reproduction of the arrangement of ridges on the skin on the underside of the hands or feet made by the transfer of materials from the skin to a surface. This report uses the term print or latent print to denote impressions from all regions of friction ridge skin unless a more specific term such as “fingerprint” or “palm print” is used.

*Latent print examination:* The study of latent and exemplar prints to help determine the source of the latent print. Because prints come from the friction ridge area of the skin on the hands or feet, latent print analysis is sometimes referred to as friction ridge analysis. As discussed below, “Analysis” and “Comparison” also have specialized meanings in “ACE-V;” therefore, this report generally uses the term “examination” rather than “analysis” or “comparison” when referring to the totality of work of latent print examiners.

*Latent print examiner:* The individual who conducts the latent print examination, also called latent print analyst.
Minutiae: Events along a ridge path, including bifurcations (points at which one friction ridge divides into two friction ridges), dots (isolated friction ridge units that have lengths similar to their widths), and ridge endings (the abrupt end of ridges), as illustrated in Table 1.1.

<table>
<thead>
<tr>
<th>Bifurcation</th>
<th>Dot</th>
<th>Ridge Ending</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Bifurcation Image" /></td>
<td><img src="image2.png" alt="Dot Image" /></td>
<td><img src="image3.png" alt="Ridge Ending Image" /></td>
</tr>
</tbody>
</table>

Table 1.1: Illustrations of some friction ridge minutiae

1.1 The ACE-V Process

In broad strokes, a latent print examination using the ACE-V process proceeds as follows: Analysis refers to an initial information-gathering phase in which the examiner studies the unknown print to assess the quality and quantity of discriminating detail present. The examiner considers information such as substrate, development method, various levels of ridge detail, and pressure distortions. A separate analysis then occurs with the exemplar print. Comparison is the side-by-side observation of the friction ridge detail in the two prints to determine the agreement or disagreement in the details. In the Evaluation phase, the examiner assesses the agreement or disagreement of the information observed during Analysis and Comparison and forms a conclusion. Verification in some agencies is a review of an examiner’s conclusions with knowledge of those conclusions; in other agencies, it is an independent re-examination by a second examiner who does not know the outcome of the first examination.

Figure 1.1, developed by members of the Working Group, describes the steps of the ACE-V process as currently practiced by the latent print examination community. The Latent Print Examination Process Map’s purpose is to facilitate discussion about key decision points in the ACE-V process. This chapter briefly describes each step in ACE-V, although the sequence of some of the steps may vary in practice.

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Figure 1.1: The Latent Print Examination Process Map

* The terms individualization and identification are synonymous in this document.
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