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Overview of special issue: Human factors in forensic science practice sourcebook

1. Introduction

The five articles in this special issue of FSI:Synergy were created to advance the understanding and adoption of insights from cognitive psychology into forensic practice. Together these articles form the "Human Factors in Forensic Science Practice Sourcebook," which the National Institute of Justice (NIJ) directed RTI International's Forensic Technology Center of Excellence to develop. Each article in this issue represents a "chapter" of this reference and is intended to address a specific field of knowledge within the cognitive psychology literature and how it may apply to and strengthen forensic science.

This sourcebook is designed to serve a wide range of forensic science stakeholders in three primary ways:

- Describe the state of knowledge of human factors as applied to forensic practice.
- Guide forensic laboratories to take into account how human factors considerations can improve the practice of forensic science.
- Inform researchers and funders about research gaps that could be addressed in the application of cognitive psychology to forensic practice.

The sourcebook was developed by a collaborative team of forensic science practitioners and cognitive psychologists, who met in person three times over two years to examine issues related to human factors in forensic science. Each article team was led by a psychologist who had expertise in the cognitive area under review, assisted by multiple forensic science practitioners who provided context and operational insights into forensic science needs and practices.

The practitioners were recruited from an open call for volunteers from the Forensic Technology Center of Excellence and were selected based on their professional standing and experience. They represent a diverse range of forensic science disciplines, including latent prints, crime scenes, controlled substances, DNA, bloodstain pattern analysis, firearms, footwear, questioned documents, fire investigation, and laboratory management. Three of our practitioners and one of our psychologists were unable to commit to the entire project and do not appear as authors on specific articles. Thus, we would like to extend our thanks to John Collins, Alison Hutchens, Dr. Linton Mohammed, and Dr. Janet Metcalfe[1] for their valuable contributions to our early discussions.

The aim of the sourcebook is to open readers' eyes to different aspects of human factors with which they may not have been previously familiar. These articles are intended to be helpful and instructive to the forensic science community and provide tools to improve the work experience and product, provide support in court, and present to laboratory management to obtain support where needed.

Note that the sourcebook does not contain strong recommendations for changes in practice. The application of cognitive psychology principles to forensic science problems is still in its infancy and, in many cases, there is not sufficient directly relevant literature to support such recommendations. Instead, we highlight areas of cognitive psychology that are relevant to forensic science practice, provide an overview of the theory and existing literature of those fields, and describe how forensic science may benefit from their application. We do speculate on some changes to practice that are likely to be beneficial and make recommendations for future research.

2. Human factors and their relevance to forensic practice

Human factors may encompass any way in which people's psychological or physiological attributes affect a system or process. Physiological considerations include things like the ergonomics of laboratory work stations or the lighting in comparison areas. Psychological considerations—which are the primary concern of this sourcebook—may include how people learn new procedures or are influenced by stress. Cognitive psychologists study how the human mind operates including capacities like attention, memory, language processing, perception, problem solving, and thinking (https://www.journals.elsevier.com/cognitive-psychology/). Thus, cognitive psychology is a subset of human factors and it can help people and organizations build robust systems based on the strengths and limitations of the human mind.

Although much of the attention forensic science has received from cognitive psychologists to date has focused on issues of cognitive bias, cognitive psychology addresses a broad array of issues relevant to forensic science such as:

- Is it possible to identify individuals who will be well-suited for various forensic professions and then train them to an acceptable standard of proficiency?

[1] Dr. Metcalfe is a psychologist with expertise in Learning from Errors and was initially our topic leader for that article. She led the discussions on this topic and provided the working group with the pertinent literature. However, because she had to leave the project before writing began, forensic practitioner Dr. Heidi Eldridge became the primary author of the Learning from Errors chapter. Dr. Eldridge participated in all discussions and read the relevant literature; she also obtained significant input from practitioner John Vanderkolk who met with Dr. Metcalfe separately to discuss the article's contents.

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- How does a pattern evidence examiner perceive and process a piece of evidence?
- Can fatigue or divided attention negatively affect the work of a forensic examiner?
- How does human memory work to enable comparison decisions?
- How can a laboratory understand the source of errors and mitigate the future impact of errors on forensic results?
- How can results be communicated to co-workers, investigators and the court in a manner that is accurate and comprehensible?

These questions, and many others, are addressed in the five articles described below.

3. Organization of the sourcebook

The sourcebook steering committee selected five current key challenges in the forensic sciences to include in this project. The articles are organized starting with those that address specific times in an analyst's career or specific tasks they are engaged in to those that address the broader context in which analysts work. The first article's topic is initial personnel selection and assessment. The second, clearly related to the first, addresses initial training and also the administration of assessments through a scientist's career. In the third, we move to the psychology underlying the everyday tasks done by feature-comparison and process analysts. The fourth article considers various ways in which a laboratory's culture and policies can affect an analyst's reactions to stressors for better or worse. Finally, we address the communication of forensic science information down the pipeline – from the time it is collected to when it may be testified to in court. Following is a high-level overview of each of these five topics.

3.1. The need for research-based tools for personnel selection and assessment in the forensic sciences

Each forensic discipline requires a unique set of knowledge, skills, and abilities (KSAs), which vary based on the demands of the specific discipline. For example, pattern evidence examiners require visual acuity and the ability to maintain mental representations of patterns in working memory, among other KSAs. Research from the fields of personnel selection and human resource management can assist in the identification and development of productive forensic examiners.

This article describes how a job analysis is used to determine the requirements of a position. Once job requirements have been established, predictors of employee performance against these requirements can be developed and used to assess candidates.

Few of these procedures have been implemented in forensic science organizations. In general, it is recommended that forensic science managers employ valid selection and assessment programs using proven methods, as outlined in the article. Also, continued research should develop personnel assessment tools and frameworks geared to the requirements of each forensic science discipline.

3.2. The benefits of errors during training

As early as the first training in their discipline, forensic scientists learn that errors are unacceptable. A trainee who makes an error may be considered unfit for the demands of forensic practice. However, research from cognitive psychology demonstrates that individuals learn most effectively when they are challenged and make errors, as long as feedback is promptly and reliably received on those errors. Although errors are not recommended during casework, they should be an expected part of a rigorous training program. Beyond the original training, later performance tests should also push the boundaries of an examiner's ability. It is important to ensure that courts will not hold training errors against an examiner.

3.3. Challenges to reasoning in forensic science decisions

Most forensic disciplines rely on the expertise of the examiner. However, it is clear that there are limits to human cognition and decision-making abilities. First, people have limits on working memory, recall, and reasoning. Perception may be biased by how sensory information is presented, as occurs with visual illusions, as well as by the conscious or unconscious consideration of extraneous or irrelevant information. Reasoning may be based on logic or on prior knowledge structures concerning people, objects, or events. We use shortcuts so that we can navigate a complex world without having to consider every detail, which would paralyze us quickly, and we rely on the human affinity for seeking patterns to help us make sense of the rest.

In general, people's interpretation of the world is based on a combination of what actually exists, on the situation we are in when we are reasoning, and on our pre-existing knowledge, experience, beliefs, and desires. Thus, qualities of individuals, procedures, and the environment can all affect task performance. Cognitive psychology research can help elucidate ways to make forensic analysis practices more compatible with human cognitive strengths and weaknesses and, therefore, more reliable.

3.4. Stressors in forensic organizations: risks and solutions

Crime laboratory leaders are aware that the culture of a forensic science organization relates directly to its public regard and the reliability of its forensic results. That said, much can be learned from cognitive psychology research and the lessons of other professions to improve laboratory culture. High reliability organizations—such as those in medicine or aviation—share key characteristics, including a preoccupation with failure, resilience, and deference to expertise. Forensic laboratories must balance operational effectiveness, quality assurance, and other variables in a culture that distinguishes among mistakes, at-risk behavior, and reckless behavior. The manager must be able to recognize the nature of errors and respond appropriately. Further, the manager must foster a system of risk management with clear standards related to the agency's values. For example, how does an examiner make subjective decisions relating to the relative risk of setting a guilty person free versus keeping an innocent person out of jail?

Additionally, in forensic science, examiners face a variety of stressors that define the culture of the laboratory as an organization. Exposure to gruesome or upsetting events, the adversarial court process, caseload size, and long work hours are just some of the relevant factors. The impact of these stressors may be mitigated by appropriate management strategies, such as transparency and improvements to culture and systems. As a high-reliability organization, forensic science laboratories must be committed to continuous improvement on an operational and a cultural basis.

3.5. Describing communication during a forensic investigation using the Pebbles on a Scale Metaphor

This article uses a case study example to illustrate the importance of careful communication to a successful investigation. Although forensic scientists must perform work in a scientific and objective manner, they must also be able to communicate clearly and effectively with colleagues and others during all steps of an investigation. For example, crime scene analysts must communicate with detectives to ensure a thorough and unbiased collection of evidence. The scene must be documented to elucidate necessary context for analysts without unnecessary or biasing information. Requests for forensic service must be clear and objective to permit appropriate testing, verification, and review. Currently, reporting language varies from discipline to discipline and laboratory to laboratory, but it must always provide sufficient clarity to aid stakeholders in decision-making without confusing or misleading them. A forensic scientist may be trained in the presentation of results in court, but all

Table 1
List of working group members and their organizations.

Name	Organization
Paul Bieber	The Arson Research Project
Thomas Busey, PhD	Indiana University
Laura Carlson, PhD	University of Notre Dame
John Collins, MA	Forensic Foundations Group
Heidi Eldridge, PhD	RTI International
Alison Hutchens	Durham PD
Jarrah Kennedy	Kansas City PD
Jonathan McGrath, PhD	National Institute of Justice
Janet Metcalfe, PhD	Columbia University
Linton Mohammed	Forensic Science Consultants, Inc
John Morgan, PhD	CopTech LLC
Luther Schaeffer, MSc	National Institute of Justice
Donia Slack, MSc	RTI International
Randall Spain	NC State University
Barbara A. Spellman, JD, PhD	University of Virginia School of Law
Jon Stimac	Oregon State Police Forensic Services Division
Laura Sudkamp	Kentucky State Police Forensic Laboratories
Melissa Taylor	National Institute of Standards and Technology
John Vanderkolk	Indiana State Police Laboratory
Alice White	Evolve Forensics, LLC
Kimberly Zeller	Houston Forensic Science Center

these previous elements of communication exist outside of that context.

Thus, even if an analysis is performed flawlessly, effective communication across these steps—and many others—is necessary to ensure the reliability of the results.

3.6. Next steps

Collaboration between cognitive scientists and the forensic science community can improve the reliability and efficiency of laboratory practice. At a minimum, forensic laboratories should consider human factors in the development of standard operating procedures and the management of personnel and systems. Ideally, forensic scientists should have training and education in the basics of cognitive psychology so that they maintain awareness of the relevant risks and opportunities while they pursue their professional work. Further research is needed to understand how to apply broader cognitive science concepts to the specific problems of forensic science. Evaluation and validation of proposed changes based on this research should occur before they are implemented. This includes documentation of best practices and mitigation of any drawbacks. Only then can we feel confident that the lessons of cognitive psychology are being appropriately harnessed to bring about positive change to forensic science practice.

We hope that this dialogue between researchers and practitioners will continue. We believe that the present work demonstrates its value and our hope is that continued collaborative research and conversations will lead to improvements in the reliability of forensic results and the professional development of its practitioners.

4. Sourcebook Contributors

4.1. Steering committee

The members of the steering committee conceived of the topic areas to be covered in this project, recruited the psychologists to take part in the project, and recruited and selected the forensic practitioners to be part of the working group. They also facilitated the working group meetings and assisted with the assignment of forensic practitioners to article sub-groups.

John Morgan, PhD – CopTech LLC.

Heidi Eldridge, PhD – RTI International.

Thomas Busey, PhD – Indiana University, Psychological and Brain Sciences.

4.2. Editors

The editors listed below managed the project, ensuring completion of articles and their internal peer-review within the working group. They also performed editorial reviews of the manuscript drafts during the submission, peer review, and revision process with *FSI:Synergy* for publication.

Heidi Eldridge, PhD – RTI International.

Barbara A. Spellman, JD, PhD – University of Virginia School of Law.

Thomas Busey, PhD – Indiana University, Psychological and Brain Sciences.

4.3. Working group members

The individuals listed in Table 1 were members of the working group that discussed these topics and contributed to the articles in this special issue. All working group members are listed here, including those who were unable to participate in the project through completion.

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