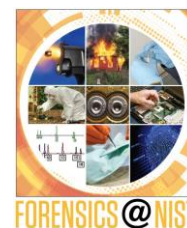


MEASUREMENT SCIENCE AND STANDARDS IN FORENSIC HANDWRITING ANALYSIS

ABSTRACTS – June 4, 2013



Forensic Handwriting Examinations: The Progression to our Current State

John Paul Osborn, Forensic Document Examiner, Osborn & Son; Peter Tytell, Forensic Document Examiner; and Rigo Vargas, Questioned Documents Section Chief, Mississippi Crime Laboratory

It is indeed fitting that this topic is being discussed at the National Institute of Standards and Technology. The pioneer document examiner Albert S. Osborn was one of the early users of the calibration services of the National Bureau of Standards (as NIST was then known), using measurement science to prove the accuracy of the latest photographic lenses and thereby overcome objections in court to the admission of properly made photographic illustrations of handwriting examinations. Just a century ago, when Osborn sent some micrometers to the NBS for calibration Dr. Wilmer Souder of the weights and measures division became interested in the subject, and for several decades was the principle federal document examiner and was called upon for advice in the creation of other federal forensic facilities at the FBI and Treasury Departments. One of the early federal examiners who followed Dr. Souder was Alwyn Cole, the author of a description of the scope of the document examiner's work that in 1972 became the first standard of the newly formed ASTM Committee E30 on Forensic Science, and for many years was its only standard.

After a period of dormancy, ASTM E30 became active again in 1989 and the questioned document subcommittee issued four more standards, two on ink examination and two terminologies, including the much used terminology for reporting opinions. In the wake of the *Daubert* decision a federally sponsored working group on questioned documents (TWGDOC/SWGDOC) was formed in 1997, interacting with ASTM Subcommittee E30.02 virtually from its inception, and from 2000 balloting its output through the ASTM process. Based on input from SWGDOC and feedback from a wide range of stakeholders and other interested individuals, E30.02 had some impressively productive years. When it was discharged in 2012 the subcommittee had 21 active standards, with a dozen more work items from SWGDOC in the ASTM pipeline and still more ready to put in the hopper.

Using ASTM as a standards development organization provided examiners many standards that have demonstrated their usefulness both when working at the bench, in a lab, and appearing before the bench in a courtroom. Forensic document examiners have recognized the need for and utility of these standards and will continue the work of developing and improving standards for the discipline.

Neuroscience behind the Motor Control and Motor Equivalence of the Handwriting Function

Michael P. Caligiuri, PhD, Professor, University of California, San Diego

Coined by Lashley more than 80 years ago, the term motor equivalence refers to observations by which an organism achieves an invariant goal by variable means. This fundamental principle of motor control suggests that motor acts are encoded in the central nervous system as abstractions rather than specific commands or strings of commands. The advantage to the organism under motor equivalence is that a particular limb or muscle/joint assembly selected to execute a complex movement need not restrain a motor program. This allows maximum flexibility and accommodation when faced with unpredictable environmental constraints. Motor equivalence is closely related with the degrees of freedom problem introduced by Bernstein in the 1930s. Bernstein recognized that there are multiple degrees of freedom within which a set of joints can move with a near infinite number of ways many movements can be performed; yet movements are quite stereotyped across individuals. His “problem” was in understanding why movements are stereotyped.

Under motor equivalence, large kinematic variability (i.e. degrees of freedom) leads to the flexible organization of movements to attain a goal. The existence of multiple redundant degrees of freedom to achieve a single goal is helpful when modeling complex movement (e.g. minimization principles). Interestingly, both Lashley and Bernstein cite handwriting as a flexible motor skill that benefits from motor equivalence. While handwriting is useful in developing general models of motor control, redundant degrees of freedom and motor equivalence can be problematic in signature and handwriting authentication.

The aims of this presentation are to provide an overview of the principle of motor equivalence and its relevance to handwriting, describe the neuroanatomic and physiologic bases underlying motor equivalence and to present preliminary findings from a study of handwriting kinematics demonstrating the effects of multiple geometric and environmental constraints on signature writing. Identifying writer-specific invariant kinematic features associated with signature writing as predicted by the principle of motor equivalence can inform the process of signature authentication.

Handwriting Stroke Kinematics

Linton A. Mohammed, PhD, D-ABFDE, Forensic Document Examiner, Forensic Science Consultants, Inc.

Albert S. Osborn, one of the pioneers of handwriting examination, was an advocate of measurements as a means of objective examinations and demonstration of evidence to a jury. Osborn designed test plates and other measuring devices for use in examinations. Forensic Document Examiners (FDEs) seldom use measurements in their examinations to the extent that Osborn described. Additionally, FDEs often infer dynamic information from static signatures and handwriting.

The NAS report stated, "The scientific basis for handwriting comparisons needs to be strengthened." One way of doing this is by measuring the dynamics of strokes and comparing the measured values to the observed descriptions of strokes in genuine, disguised, and simulated handwriting. The empirical information may validate or dispute what has been described by some as anecdotal evidence. Research using a combination of specialized software and digitizer tablets will be presented and results of dynamic measurements of handwriting will be demonstrated and discussed.

Further avenues of research that will strengthen the basis of handwriting examination will be discussed. Such areas include the effects of impairment such as age, illness, alcohol, medication, and drugs on handwriting and the difficulties they present to FDEs in casework. Additionally, the research may aid the FDE's decision-making in casework by providing a more objective framework for examinations.

Homogeneous Writing Research

Marie Durina, Senior Forensic Document Examiner, San Diego Sheriff's Crime Laboratory

This presentation is based on a research project where samples of writing were obtained from over 50 writers, who grew up in the same neighborhood, were taught the same copybook style (the Palmer system), at the same Catholic elementary school, by the same teachers, approximately four decades ago.

The presentation will cover the challenges encountered by forensic document examiners when rendering conclusions of authorship on handwriting obtained from a homogeneous writing population, and possible sources of errors when examining such writings.

In this research study, the submitted specimen writings obtained from former students and teachers from the same school were subsequently examined and compared by a group of 49 forensic document examiners throughout the world. The examiners rendered conclusions of authorship on the writings and submitted their conclusions on an answer sheet for grading.

The study sought to find supporting evidence that:

- 1) There is a high degree of inter-writer variation among writers, even in populations where the driving forces for variation are low; and
- 2) Among these homogeneous writing populations, forensic document examiners would still be able to extract features from the writing samples that would enable them to attribute authorship.

The research also addressed answer criticisms that earlier studies on the individuality of handwriting did not include populations from "homogeneous writing communities", and relied on computer analysis of handwriting, rather than on human examiners.

Overall results of the study will be discussed, including how well human examiners performed as a group in making distinctions among the writing specimens. Factors affecting results that

will be discussed include examiners' experience level, geographic location of the practicing examiners and attendant effects on the examiners' knowledge of a particular handwriting system, and the length of the questioned documents submitted for examination. Potential sources for error in certain problematic samples will also be discussed.

Lineup: The Reliability of Examinations Involving Multiple Suspected Writers

David Parrett, Forensic Document Examiner

A 1999 United States District Court ruling suggested possible bias in one-on-one questioning to known suspect document examinations. The ruling was, in part, a result of document examination critic Mark Denbaux's assertion that an examination of the writing of several persons similar to a police "lineup" might produce a different opinion by the examiner. In contrast to the traditional police "lineup" of a few individuals, this study employed the writing of one-thousand (1,000) "suspects". Examiners were provided a questioned document consisting of a "London Letter". They were given the task of determining if the questioned author's handwriting was among the one-thousand "London Letters" gathered from different writers. This paper reviews the result of those comparisons and the implications to handwriting identification validation.

The Forensic Language-Independent Analysis System for Handwriting Identification (FLASH ID)

Mark Walch, Gannon Technologies Group, and Donald Gantz, PhD, George Mason University

FLASH ID is a fully functional software application that automatically identifies writers by their handwriting. FLASH ID works by maintaining a database of information derived from *reference* handwriting and determining whether a new, unidentified writing specimen such as a questioned document matches any of the writings in the database. FLASH ID operates on a conventional personal computer platform—including laptops. Questioned documents subjected to biometric analysis are scanned and passed to FLASH ID as image files. Once the image has been captured, FLASH ID distills the biometric content from the handwriting, compares this content to reference samples stored in a database, computes scores representing biometric similarity and compiles the results in a ranked list of all writers from the database. The writer at the top of this list bears the strongest similarity to the writer of the captured specimen.

Functionally, FLASH ID finely segments the writings within the loaded images. Adjacent segments are combined into *graphemes* which are the bases for analysis. Graphemes may be parts of characters, whole characters or groups of characters. Graph-matching algorithms at the core of the technology classify the graphemes, first, by their *topology* and, second, by their *geometric features*. Topology includes the structure of graphs in terms of their edges and vertices—links and nodes—and their quantity and connectivity. Geometric features address the shapes of curves. Physical measurements on the graphemes make up associated feature vectors. The power to distinguish an individual's writing from that of other writers is derived from statistical analysis of the topological and geometric characteristics of the individual's

writings as well as from the statistical analysis of feature vectors within each particular topology and geometry combination.

FLASH ID consists of two modules: (1) the Database Builder and (2) the Matcher. The FLASH ID Database Builder pre-processes reference writing samples and builds an identification database from statistical analyses of the topology, geometry and features of graphemes. The FLASH ID Matcher uses this database to process questioned documents and identify the writer in the database who best matches a questioned document. Both FLASH ID modules are designed to scale across multiple computers to handle higher volumes.

There are two operational versions of FLASH ID. The document examiner version provides specific visual grapheme level feedback concerning similarities of writings and supports exporting of annotated images and reports. The web services version can be integrated into other systems for the analysis of handwriting and provides writer identification results for submitted writing samples.

D-Scribe

Matthias Schulte-Austum, Siemens AG, Senior Software Development Engineer and Siemens Key Expert Pattern Recognition

Siemens has developed D-Scribe, a robust technology to recognize handwriting that combines high accuracy, simple operation, and immediate results that can directly assist novices in identifying the specific authors of handwritten materials. The core technology is proven, mature, and already in use for the digital conversion and interpretation of handwriting in different automation areas. D-Scribe is a multi-platform capability has been implemented on various platforms from notebook to Smartphone.

A missing feature was the clustering of similar handwriting samples in order to support the identification of documents from the same author. New algorithms were now implemented and tested on different test decks:

- a) 2535 documents from 507 writers in English- 5 predefined texts and an arbitrary text per writer
- b) 5000 documents of 45 writers with a large variety of documents in Arabic
- c) 850 Documents from 599 writers containing blind documents without a known writer and very few documents per writer

Feature sets with 4 and 6 features (different grapheme features, hinge features and other) were built up and applied to the different test decks. We will present the clustering quality score defined to identify the optimum of applicable feature sets. In particular, the Manhattan Distance with Ward's Linkage Clustering works best on the given test samples. An important aspect is that separation of language/font groups can be best performed based on these algorithms.

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Trends in Frequency Occurrence of Handwriting and Hand Printing Characteristics

Thomas W. Vastrick, Forensic Document Examiner

NIJ Research Grant 2010-DN-BX-K273 is better known as “Frequency Occurrence in Handwriting and Hand Printing Characteristics”. The research is the culmination of years of discussions, studies of court decisions and judge’s comments, review of statistical research and a desire for proactive action. The ideas for this study preceded the NAS Report, which further validated the need for this work. The grant is administered by the National Center for Forensic Science (NCFS) at the University of Central Florida in Orlando, FL. NCFS is a research center dedicated to the forensic sciences to which Mr. Vastrick had volunteered his services for several years.

By design, this study is considered statistical research into handwriting comparisons as opposed to a forensic science study using statistics. The difference is that staff statisticians are the driving force behind the methodologies that are utilized. Each step of the project has gone through rigorous pilot studies in order to provide results with the lowest possible error rate. For example, the collection of handwriting specimens themselves are the product of a stratified random-based process utilizing intrinsic and extrinsic factors as outlined in *Handwriting Fundamental* by Huber and Headrick. This collection of specimens is considered statistically to be representative of the population within the United States.

Each feature that has been selected for use in this project were personally selected by a group of certified forensic document examiners then run through several Attribute Agreement Analyses tests in order to provide statistical evidence that the selected specimens are not subjective. Only features that were 100% reproducible within the AAA pilot studies are being used in this project.

Forensic document examiners are inputting the data into a specially designed database under the independent control of a database specialist. The data is collected and collated by the database specialist and submitted directly to the statisticians for frequency analyses. At no time is the data collectively in the hands of any forensic document examiner, thereby preventing any legitimate suggestion of impropriety of the data.

The results of this project will be a list of statistical frequencies for numerous handwriting and hand printing features that will be available for use by examiners in everyday casework and in court to demonstrate the level of uniqueness for any given handwriting.

Error, Confidence and (Un)certainty – Deconstructing Authorship Opinions Using a Forced-Call Testing Protocol

Brent Ostrum, Senior Forensic Document Examiner, Canada Border Services Agency

The issue of potential error and uncertainty in the opinions expressed by forensic handwriting examiners (FHE) should be of interest to all practitioners. These concepts are relevant whether an examiner expresses an opinion in the form of posterior probabilities/odds such as the approach outlined in ASTM E1658, or as some form of likelihood-ratio (LR).

This presentation will discuss a forced-call testing protocol intended to “decouple” the authorship call (opinion) from the confidence rating for that call. This approach permits a more in-depth analysis of the relationship between confidence and error helping to clarify the meaning of the confidence scale embodied in E1658. At the same time, it provides a possible framework for the empirical justification of any multi-level opinion scale.

There will be some discussion of issues and concerns relating to testing, potential error and uncertainty in authorship opinions, including suggestions as to how uncertainty might be expressed more clearly in FHE conclusions. The goal of this talk is to promote better understanding and further discussion about error and uncertainty in both the FHE evaluation process and the resulting opinions.

Understanding Individuality of Handwriting Using Score-Based Likelihood Ratios

Christopher Saunders, PhD, Mathematical Statistician, South Dakota State University

Recent studies in automated forensic handwriting identification have shown that for a given value of the evidence, subtle changes in conditioning arguments regarding the defense proposition can often lead to radically different values of the so called Score-Based-Likelihood-Ratios (SLR). Within the forensic literature there are three general classes of SLR's. While each of the proposed SLRs has advantages and disadvantages; they are at best only approximations to a true LR in a Bayesian decision theoretic sense. In our estimation, it is best to resist the idea of a “universally correct” SLR. This presentation will review the different types of SLR's currently being used in forensic science, discuss strategies for implementing them for forensic handwriting analysis, and review some of the problems related to the interpretation of the resulting SLRs.

The Development of Individual Handwriting Characteristics and the Statistical Evaluation of Different Combination Likelihoods of These Individual Characteristics

Lisa Hanson, Forensic Document Examiner, Minnesota Bureau of Criminal Apprehension Laboratory

This research project is being conducted to find a clearer understanding of the time period involved and the development of individual handwriting characteristics within children's cursive and printed writing. This study is being conducted over a three year span; The first year when the most intense instructions are given and Copy Book is used as a visual example; The second

year when the Copy Book is removed and is not visually available or needed by students; And the third year as students are expected to develop additional individual handwriting characteristics. There is a request that this study be expanded to follow the initial second graders through their senior year of high school; however this is will not be known until a later date.

Handwriting and hand printing is being collected from over 2000 students who each produce four paragraphs of writing each; 2 cursive paragraphs and 2 printed paragraphs. This process is being repeated three times; toward the end of each school year from 2012 – 2014. By tracking each student's writing habits every year and by having the students produces the same requested paragraph year after year; all the writings collected will be intra-comparable to each student as well as comparable to all of the other student's writings.

Lisa Hanson, as well as other qualified Forensic Document Examiners, have and will identify individual characteristics as they develop in each student's writing samples. The samples are scanned and then analyzed using handwriting software called iFOX. The data collected using iFOX is then statistically analyzed to develop likelihood ratios. These likelihood ratios will detail how often one will expect to see these individual characteristics and/or combinations of these individual characteristics.

The data and results from this study will be used to validate one of three basic statements made by Forensic Document Examiners when they are asked to explain why handwriting comparisons are able to be conducted. The first being no two people write exactly the same. The second being no one person writes exactly the same way twice. And the third is that individual handwriting habits and/or characteristics develop as students move away from the Copy Book style s/he is taught in school. It is this last statement that will be statistically validated by this research.

Handwriting Evidence Evaluation Based on the Shape of Characters: Application of Multivariate Likelihood Ratios

Raymond Marquis, PhD, Institute of Forensic Science, University of Lausanne

A novel Bayesian methodology has been developed to quantitatively assess handwriting evidence by means of a likelihood ratio (LR) designed for multivariate data. This methodology is presented and its applicability is shown through a simulated case of a threatening anonymous text where a suspect is apprehended. The shape of handwritten characters *a*, *d*, *o*, and *q* of the threatening text was compared with characters of the true writer, and then with two other writers, one with similar and one with dissimilar characters shape compared to the true writer. In each of these three situations, 100 draws of characters were made and the resulting distributions of LR were established to consider the natural handwriting variation. LR values supported the correct hypothesis in every case. This original Bayesian methodology provides a coherent and rigorous tool for the assessment of handwriting evidence, contributing undoubtedly to integrate the field of handwriting examination into science.

Presenting Quantitative Techniques and Conclusions in Court

Kenneth E. Melson, Professional Lecturer in Law, George Washington University Law School and Office of the Inspector General, U.S. Postal Service

The 2009 National Academy of Sciences report on the status of forensic science in the United States clearly articulated the need for more research to truly establish a scientific foundation for many of the forensic science disciplines. The report recommended that many of the pattern disciplines move away from purely subjective, qualitative assessments to more objective, quantitative analyses. Noting the limited research to date to support the scientific basis of handwriting comparison, its reliability and replicability, the authors of the report suggested there may still be "some value" to handwriting analysis.

While many in the forensic document examination community may disagree with the report's characterization of the value of handwriting analysis, there can be little doubt that there is an urgent need to better express the results of the comparisons in a more quantitative method. On-going research projects described during this conference are developing methodologies for quantitative expressions of source attribution.

This presentation will describe a predictive analysis of the judicial reaction to quantitative evaluations relating to the identification of handwriting and hand printing. How might the courts receive new methods of deriving statistical meaning from quantitative determinations in this pattern discipline? How do the *Daubert* factors affect the admissibility of such evidence, particularly in light of its novel character in the field of forensic document examination? Will such testimony have more favorable treatment under the *Frye* rule?

This predictive analysis of judicial receptivity will start with the famous California case involving a blond woman, a man with facial hair, and a yellow Lincoln. From there the speaker will trace the development of judicial reactions to quantitative analyses using case examples regarding not only the mathematical foundation for the probabilities presented in court but the use and misuse of probabilistic expressions. Lessons can be learned from these cases, the DNA wars, and the current attempts by other disciplines to add greater objectivity to the analyses of forensic evidence. It is hoped that this instructional discussion will benefit researchers and practitioners in their quest for admissible, quantitative evidence demonstrating the probative value of handwriting comparisons.

Using the Statistical Functions of Write-On² Software to Assess Natural Variation in Handwriting

Brian Lindblom, Forensic Document Examiner, Document Examination Consultants, Inc., Ottawa Canada

Write-On² software is a database that assists forensic document examiners in the collection, dissection and analysis of handwriting. Occurrence Charts that show all instances of a particular character or combination of characters are generated through sophisticated searches. Within the program Word and Segment Indexes are available from which searches can be launched. Included in the indices are columns showing the number of occurrences in both the questioned and sample material. This statistical information is very helpful in assessing natural variation in

handwriting. For example, one can readily determine how many occurrences of a given letter combination appear in the documents and weight findings accordingly. From the Occurrence Charts the FDE is directed to the location of a given character within the original documents. Unlike doing traditional side-by-side comparisons, the FDE does not have to be concerned with the possibility that one or more examples of a letter may have been missed within the questioned and/or sample material.

This presentation illustrates how Write-On² can assist the FDE in an efficient assessment of the handwriting and alleviate pointless searches for characters that are absent from the sample material. Other strengths of Write-On² will also be explored, including the ability to demonstrate results in a courtroom setting and to show flawed methodologies and observations that may have been made by an opposing expert.

Scanned Images: How Well Do They Depict the Subtle Features in Handwriting?

Janet Fenner Masson, Forensic Document Examiner

It is increasingly common for companies and government agencies to retain scanned images of documents in lieu of originals. In many cases, the original documents are destroyed after imaging. As a result, the best image available for examination by a forensic document examiner may be a digital image.

This project is a study of digital images captured utilizing guidelines like those routinely used by companies and agencies in maintaining records. The focus of the project was to determine which features are reliably and accurately depicted in these scanned images and which are not. A comparison of the image quality obtained with various scanning parameters and transmission methods was made. In addition, examinations from originals, from first generation photocopies, and from scanned images were considered. The ultimate purpose of the study was to assist document examiners in making an examination of a document for which the original has been lost or destroyed and the best evidence still available is a scanned image.

Current Bank Check Scanning Practices

Jane Lewis, AAFS-QD Section Director, Private Examiner

Current bank check scanning practices will be discussed. Attendees will learn about the history of Check Clearing for the Twenty-First Century, also known as Check 21. The examination of images of checks with current bank check scanning practices will be described. Implications of scanned low resolution versus higher resolution images of checks as they relate to forensic document examination will be presented.

Forensic document examiners will receive information about the existing bank check scanning practices. They will be made aware of the resolution and image types used by banks to scan and save images of checks. Images of bank check scanning equipment will also be presented.

Scanning parameters of resolution and image type used by banks (including black and white versus grayscale or color) and their limiting effects precluding a thorough examination by a forensic document examiner will be discussed.

Forensic document examiners will appreciate the current state of bank check scanning practices in the United States and internationally.