This document sets forth background materials on the scientific research supporting examinations as conducted by the forensic laboratories at the Department of Justice. It also includes a discussion of significant policy matters. This document is provided to assist a public review and comment process of the related Proposed Uniform Language for Testimony and Reports (posted separately). It is not intended to, does not, and may not be relied upon to create any rights, substantive or procedural, enforceable by law by any party in any matter, civil or criminal, nor does it place any limitation on otherwise lawful investigative and litigative prerogatives of the Department.

SUPPORTING DOCUMENTATION FOR DEPARTMENT OF JUSTICE PROPOSED UNIFORM LANGUAGE FOR TESTIMONY AND REPORTS FOR THE FORENSIC HANDWRITING ANALYSIS DISCIPLINE

Background

The value of handwriting comparisons has been recognized since it was codified by the Romans in the 6th century. The Justinian Code spelled out the rule for the comparison and identification of handwriting and allowed the judge to call on (e)specially skilled persons to give testimony as to the genuineness of handwriting.[1] The earliest record of expert handwriting comparison being accepted in a court in America was under the Civil Code of Louisiana, in *Sauve v. Dawson*[2] in 1812. Studies have indicated that lay handwriting identification is not as accurate as expert handwriting identification,[3] and at least one State Supreme Court has agreed. [4]

Theory of Handwriting Analysis

The act of producing handwriting involves a combination of sensory neurological and physiological impulses. This ability varies from one person to another. Once this skill is mastered, handwriting becomes a subconscious act and the writer interjects his own individual characteristics that are repeated from one writing to the next.[5]

Handwriting identification is based on the following three premises – (1) No two writers share the same combination of handwriting characteristics, given sufficient quantity and quality

[1] THE ENACTMENTS OF JUSTINIAN. THE CODE. Book IV. S.P. Scott, *The Civil Law*, XIII, Cincinnati, 1932. http://webu2.upmf-grenoble.fr/DroitRomain/Anglica/CJ4_Scott.htm . Viewed on 09/13/2013.

[2] *Sauve v. Dawson*, 2 Mart. (o.s.) 202 (1812).

[3] Inbau, *Lay Witness identification of Handwriting*, 34 Ill. L. Rev. 433 (1939); Kam, M., Wetstein, J., Conn, R., "Proficiency of Professional Document Examiners in Writer Identification." *J Forensic Sci*, JFSCA, Vol. 39, No. 1, January 1994, pp 5-14; Kam M, Fielding G, Conn R. Writer Identification by Professional Document Examiners. J Forensic Sci 1997; 42(5):778-786; Kam M, Gummadidala K, Fielding G, Conn R. Signature Authentication by Forensic Document Examiners. J Forensic Sci 2001; 46(4):884-888; Sita, J., Found, B., and Rogers, D., Forensic Handwriting Examiners' Expertise for Signature Comparison, J Forensic Sci (2002) 47:1–8; Kam M, Lin E, Writer Identification Using Hand-Printed and Non-Hand-Printed Questioned Documents, J Forensic Sci, November 2003, Vol. 48, No. 6, Paper ID JFS2002321_486.

[4] *Huff v. State*, 437 So. 2d 1087, 1080 (Fla. 1983).

[5] Harrison D, Burkes T, Seiger, D, Handwriting Examination: Meeting the Challenges of Science and the Law, Forensic Science Communications, October 2009, Volume 11, Number 4.

of writing (Individuality), (2) No writer can exactly duplicate his or her writing when repeating (Variation), and (3) No writer can immediately exceed his or her skill level of writing (Writing Skill). Handwriting examinations can never determine such traits as age, sex, personality, or intent.[6]

A. Three Principles of Handwriting Comparison

1. Individuality

The theory that no two writers share the same combination of handwriting characteristics is a premise that, like many other scientific premises, cannot be empirically proven. However, to date, no known scientific publications exist to contradict the premise that no two writers share the same combination of handwriting characteristics.

The *principle of individuality* forms the basis for handwriting comparison. In 1929, Albert S. Osborn, a pioneer in the field of questioned documents, described the individuality and the subconscious and habitual nature of handwriting as a combination of muscular habits and mental patterns that differs in individuals. He emphasized when identifying handwriting it is "the *combination* of particulars that identifies, and necessarily the more numerous and unusual the various elements and features the more certain the identity."[7] Osborn provided guidance on the many features to consider when examining handwriting.[8]

2. Variation

No one person writes exactly the same way within several repetitions of writings.[9]

The duration, extent, and speed involved in the coordination of an activity such as handwriting are so complex and may be combined in so many ways that it is virtually impossible to duplicate all parameters exactly. In this way, a variation in performance can and will occur between repetitions of an action by the same person.[10] Specifically, "there is a natural variation in (the) balance due to the nature of sensori-motor tasks. Therefore, a variation in the performance of a task can and will occur (within limits) between copy- to-copy of a performance by the same person. This finds implications in handwriting in the appearance of a variation in letter form and quality within the writing of one individual from execution to execution."[11]

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[6] ASTM International E2290-07a, Standard Guide for Examination of Handwritten Items, Approved: April 15, 2007. Published: July, 2007.

[7] Osborn, A. S. *Questioned Documents.* 2nd ed. Nelson-Hall, Chicago, 1929, p. 251.

[8] *Id*. At 137-139.

[9] Rhodes III E, The Implications of Kinesthetic Factors in Forensic Handwriting Comparisons. Dissertation For D.Crim., University of California, Berkeley, 1978.

[10] *Id.* at 140.

[11] *Id*. at 82.

3. Writing Skill

The third principle of handwriting analysis is skill level, or the writer's ability to physically reproduce the letter formations he or she visualizes. Skill level is not necessarily related to legibility. "One of the aspects of writing by which its excellence (skill) is judged is its uniformity. The lack of uniformity affects appearance even to the point of the writings legibility. Uniformity or the lack of it is observed in alignments, letter slopes, and the consistency of shape in repeated letters or in different letters having common elements."[12]

Analyzing an individual's known writing, including prior writing examples, enables Forensic Document Examiners (FDEs) to assess and evaluate the individual's skill level.

B. Validation Studies

One abiding hypothesis in the handwriting discipline is that no two individuals share the same set of handwriting characteristics. This hypothesis continues to be tested. Validation studies involving handwriting comparisons have been accomplished in two areas: individuality of handwriting and the expertise of FDEs.

1. Individuality of handwriting

a. Frequency of occurrence

The *principle of individuality*, also known as the *principle of uniqueness*, forms the basis for handwriting analysis. Osborn stated "only a small proportion of the vast variety of forms in writing can be accounted for by tracing them back to a parent system. Thousands of these characteristics are individual inventions and developments. This curious and unaccountable variation is of course what gives to handwriting its highly distinctive individuality, and it is undoubtedly true that every developed and mature handwriting shows peculiarities which, in combination of all the various characters and their modifications, cannot be exactly duplicated in the writing of any other person." [13] Multiple studies demonstrate the principle of uniqueness,[14] and these studies have demonstrated the frequency of occurrence of handwriting characteristics. Additionally, Dr. Sargur Srihari and colleagues, using CEDAR-FOX,[15] conducted an extensive study of 1500 individuals and concluded that the writer of a particular sample can be identified with 98 percent confidence using only 8 characteristics. Inferring these statistics over the entire U.S. population, writer identification can be established with 96 percent confidence. Srihari

[12] Huber, Roy A., Headrick, A. M., *Handwriting Identification: Facts and Fundamentals*, p116, 1999.

[13] Osborn, A. S. *Questioned Documents.* 2nd ed. Nelson-Hall, Chicago, 1929, p. 229.

[14] Livingston, O. B. Frequency of certain characteristics in handwriting, pen-printing of two hundred people, *J Forensic Sci* (1963) 8:250–258; Muehlberger, R. J., Newman, K. W., Regent, J., and Wichmann, J. G. A statistical examination of selected handwriting characteristics, *J Forensic Sci* (1977) 22:206–215; Huber, R. A. *The Uniqueness of Writing*. Presented at the American Society of Questioned Document Examiners annual meeting, San Jose, California, 1990; Horton, R. A. A study of the occurrence of certain handwriting characteristics in a random population, *International Journal of Forensic Document Examiners* (1996) 2:95–102.

[15] CEDAR-FOX is a handwriting software technology.

suggested that "by considering finer features, we should be able to make this conclusion with a near 100 percent confidence [that the writer can be identified]."[16] Another study conducted by a forensic document examiner examined writing samples from 52 adult writers 40 years after attending the same elementary school and taught the same copybook style of writing. The samples were examined by 49 forensic document examiners throughout the world who observed a high degree of inter-writer variation among samples that enabled them to attribute authorship.[17]

b. Twin Studies

Several twin studies[18] have compared the handwriting of twins and other individuals of multiple births. Twins typically share the same environmental influences, study in the same school systems at the same time, and, in the case of identical twins, share the same DNA. When these conditions are present, one would expect the handwriting of twins to be more similar than the writings of any other individual, and these studies demonstrate that twins have been found to share a high degree of similarity in their handwriting. Additionally, these studies, which involved more than 200 sets of twins, all found that trained FDEs were able to distinguish between all of the twins' writings.

Further, in 2007, a study titled "Handwriting of Monozygotic and Dizygotic Twins" was published in the *Problems of Forensic Sciences*. This study involved 54 pairs of twins, 31 Monozygotic (MZ) and 23 Dizygotic (DZ) twins. The objective of this study was to determine whether the handwriting of DZ twins contained more similarities than the handwriting of MZ twins. The study found that "although in both groups of twins, individual examples of strikingly similar writings appeared, especially in terms of their general appearance, the examination revealed a predominance of differences over similarities in both MZ and DZ groups of twins.[19]

An additional study by Srihari and colleagues in 2008[20] further supported the principle of individuality and involved the evaluation and comparison of handwriting by twins. Writing samples were obtained from 206 pairs of twins from 150 different cities and seven different countries, as well as 412 individuals ("nontwins") from the general U.S. population. The study evaluated four areas: (1) comparison of twins' handwriting with those of nontwins, (2) comparison of writings in which the textual content of the writing was different, (3) comparison of fraternal and identical twins' handwriting, and (4) comparison of system versus human performance. The CEDAR-FOX system was again used to evaluate the handwriting for the same

[16] Srihari, S. N., Cha, S.-H., Arora, H., and Lee, S. Individuality of handwriting, *J Forensic Sci* (2002) 47:856–872.

[17] Durina M, Caliguri M, The Determination of Authorship from a Homogenous Group of Writers, Journal *of the American Society of Questioned Doument Examiners, Inc.*, Volume 12 Number 2, December 2009, pp. 77-90.

[18] Beacom, M. S. A study of handwriting by twins and other persons of multiple births, *J Forensic Sci* (1960) 5:121–131.; Gamble, D. The handwriting of identical twins, *Canadian Society of Forensic Science Journal* (1980) 13:11–30.; Boot, D. An investigation into the degree of similarity in the handwriting of identical and fraternal twins in New Zealand, *Journal of the American Society of Questioned Document Examiners* (1998) 1(2):70–81.

[19] Dziedzic, T., Fabiansa, E., Toeplitz, Z. "Handwriting of Monozygotic and Dizygotic Twins," *Problems of Forensic Sciences*, 2007, pp. 30-34

[20] Srihari, S., Huang, C., and Srinivasan, H. On the discriminability of the handwriting of twins, Journal of Forensic Sciences (2008) 53:430–446.

style and macro- and micro-features as in the previous study, as well as for additional features not previously evaluated. The system verification error rate for twins was higher than that of nontwins, and the system verification error rate for nontwins was consistent with Srihari et al.'s previous study. The study also found that the system performed better than the layperson but was unable to reach the performance level of the qualified expert.[21]

2. Expertise of FDEs

Studies have indicated that trained FDEs are more accurate in conducting handwriting examinations than the layperson. Professor Moshe Kam, et al, of Drexel University and Dr. Bryan Found, et al, of La Trobe University conducted numerous studies supporting the expertise of conducting handwriting comparisons.[22] This research involved the examination, by FDEs and laypersons, of cursive writing, hand printing, and signatures, and the studies demonstrated that the FDE's outperformed the laypersons on specific tasks.

Handwriting Comparison Process

There are different methodologies and processes for conducting a handwriting examination. The Department shares information regarding some appropriate processes below. The Department does not suggest that the processes outlined here are the only valid or appropriate processes.

When conducting handwriting examinations (cursive writing, hand printing, signatures, or extended writing) Department personnel use an Analysis, Comparison, Evaluation, and Verification process (ACE-V).

Each analysis begins with an independent examination of the questioned and the known writing using proper lighting and magnification to determine if the writing is original writing (e.g., ink on paper) and whether it exhibits the characteristics of freely and naturally prepared writing. Additionally, each body of writing is examined to assess internal consistency, comparability, and variation and to determine the presence or absence of individualizing characteristics. The most suitable writing for comparison is text void of any attempt to disguise and/or distort the writing; however, any writing can be of value for comparison.

Once an FDE completes the analysis and determines that the questioned and known writings are suitable for comparison, the examination process progresses to a side-by-side comparison. The FDE observes the features exhibited in the bodies of writing to determine if significant

[21] *Id.*

[22] Kam, M., Wetstein, J., Conn, R., "Proficiency of Professional Document Examiners in Writer Identification." J Forensic Sci, JFSCA, Vol. 39, No. 1, January 1994, pp 5-14, Kam M, Fielding G, Conn R. Writer identification by professional document examiners. J Forensic Sci 1997; 42(5):778-786, Kam M, Gummadidala K, Fielding G, Conn R. Signature authentication by forensic document examiners. J Forensic Sci 2001; 46(4):884-888, Sita, J., Found, B., and Rogers, D., Forensic Handwriting Examiners' Expertise for Signature Comparison, *J Forensic Sci* (2002) 47:1–8, Kam M, Lin E, Writer Identification Using Hand-Printed and Non-Hand-Printed Questioned Documents, J Forensic Sci, November 2003, Vol. 48, No. 6, Paper ID JFS2002321_486.

similarities or differences exist. FDEs will evaluate the combination of individual and class characteristics between the submitted items, and determine if the variation and skill level in the questioned writings are within the limits set by the known writing. FDEs will evaluate the similarities, differences, and limitations in order to determine their significance individually and in combination. FDEs will then form a conclusion based on results of the above analyses, comparisons, and evaluations. The ability to discern minute form differences in two writings can be established through form-perception testing. Form-perception tests, also referred to as form-blindness tests, consist of geometric shapes and handwritten words and are used to establish the FDE's ability to distinguish minute differences in forms, angles, and sizes.[23]

The characteristics FDEs consider when conducting comparisons are the subtle, subconscious habits of the writer, such as writing in relation to the baseline, the overall formation of the letters, the heights of letters in relation to one another, the manner of connecting letters, the size and spacing of letters, the beginning and ending strokes, pen pressure, and other handwriting characteristics. The FDE does not consider misspellings as individualizing characteristics of the handwriting. The next step in the methodology involves evaluating the significance of the nature and combination of the handwriting characteristics. This evaluation, based on the FDE's training, knowledge, and experience, is the formation of an opinion resulting from the examiner's observations, assessments, and documentation generated during the analysis and comparison steps. The observation and assessment refers to the examiner's interpretation of the features found to be either in agreement or disagreement between two samples of handwriting in order to come to an opinion. This opinion is supported by the examiner's ability to assess the frequency of features and rarity of configurations present within the handwriting. Typical opinions that may be reached are: Identification, May Have, No Conclusion, May Not Have, or Elimination.

It is not always possible to render an opinion of identification or elimination based on the nature of the questioned and known writing provided for examination. These limitations can include evaluation of photocopied specimens, which yield poor detail and clarity and prevent the FDE from properly assessing line quality, connecting strokes, letter formations, and beginning and ending strokes. Limitations can also include distorted or disguised writing, which does not exhibit the normal handwriting characteristics of the writer; limited questioned and/or known writing, which may not allow proper assessment of skill level and identifying characteristics; questioned writing which is so simplistic as to be easily imitated; lack of comparable known writing, which does not allow for a thorough comparison of the characteristics observed in the questioned writing; and prior chemical testing on the document, which may hamper subsequent examinations.

The final step in the examination process is verification. In this step, another qualified FDE conducts a technical review of the examination records and laboratory report to ensure they conform to the technical procedures and applicable portions of his or her own agency's quality management documents and standards. An additional quality assurance measure is blind verification, which is the independent application of ACE to questioned documents comparison

[23] Osborn, A. S. The Problem of Proof. 2nd ed. Nelson-Hall, Chicago, Illinois, 1975, pp. 491–501.

by another qualified examiner with limited awareness of the details of the case and no knowledge of the conclusion of the primary examiner.

Prior to the report of examination being issued, an administrative review is also conducted to ensure accuracy and adherence to established practices and procedures, and for spelling and grammatical accuracy.

The FDEs conduct their examinations in accordance with their own agency's quality management documents and standards. Typically, these procedures may reference American Society for Testing and Materials (ASTM) Standard E2290, "Standard Guide for Examination of Handwritten Items," which is a court-recognized standard for the discipline. With respect to handwriting comparison, the Department adheres to published recommendations of the Scientific Working Group for Forensic Document Examination (SWGDOC). SWGDOC, which is composed of private examiners and government examiners in local, state, and federal laboratories throughout the United States and also internationally, has developed standards and guidelines in the field of forensic document examination.

Policy Considerations

In 2006, Congress authorized the National Academy of Sciences (NAS) to conduct a study on forensic science which culminated in a 2009 report.[24] Regarding handwriting comparisons, the report states: "The scientific basis for handwriting comparisons needs to be strengthened.[25] Recent studies have increased our understanding of the individuality and consistency of handwriting and computer studies[26] and suggest that there may be a scientific basis for handwriting comparison, at least in the absence of intentional obfuscation or forgery. Although there has been only limited research to quantify the reliability and replicability of the practices used by trained FDEs, the committee agrees that there may be some value in handwriting analysis."[27]

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[24] National Research Council. Strengthening Forensic Science in the United States: A Path Forward (Summary on Questioned Documents Examination section from Chapter 5). National Academy Press: Washington, D.C. (http://www.nap.edu/catalog/12589.html).

[25] *Id.* at 166, citing Kam, M., Fielding, G., and Conn, R. 1997. Writer identification by professional document examiners. J Forensic Sci 42(5):778-786, reports on proficiency tests given to more than 100 questioned document examiners and to a control group of individuals with similar educational backgrounds. Each subject made 144 pair-wise comparisons. Although the study showed that document examiners are much more accurate than lay people in determining whether or not two samples "match" (based on the "identification" and "strong probability" definitions of ASTM standard E1658), professionals nonetheless declared an erroneous match in 6.5 percent of the comparisons. A similar, more recent study, focusing on whether individual signatures were genuine, is reported in J. Sita, B. Found, and D. Rogers. 2002. Forensic handwriting examiners' expertise for signature comparison. J Forensic Sci 47:1117. That study found that professional handwriting examiners erred in 3.4 percent of their judgments.

[26] *Id.* at 166, citing *e.g.* Sargur, S. N., Cha, S. H., Arora, H., and Lee, S. 2002. Individuality of handwriting. J Forensic Sci 47(4):1-17.

[27] National Research Council. Strengthening Forensic Science in the United States: A Path Forward (Summary on Questioned Documents Examination section from Chapter 5). National Academy Press: Washington, D.C. (http://www.nap.edu/catalog/12589.html)NAS Chap. 5 pg at 166-167.

Post-NAS report research in the handwriting discipline is reflected in several publications.

Michael P. Caligiuri and Linton A. Mohammed's "*The Neuroscience of Handwriting: Applications for Forensic Document Examination*"[28] details the neuroanatomical and neurochemical bases of motor control and handwriting movements. In it they state "Convergent findings from lesion, neurosurgical, and functional neuroimaging research support the existence of a network of cortical and subcortical regions that govern handwriting movements." Other publications have also addressed the neuromuscular processes involved in handwriting production. Rejean Plamondon, et al. stated "The generation of handwriting is a complex neuromotor skill requiring the interaction of many cognitive processes."[29] They discuss the learning process for writing behaviors of young children and the effects of aging on adult writers. Review of neuroimaging studies in "Examining the Central and Peripheral Processes of Written Word Production Through Meta-Analysis"[30] by Jeremy J. Purcell, et al. "identify a network of left hemisphere frontal, parietal, and temporal sites that are reliably and consistently associated with written word production."

The Forensic Language-independent Analysis System for Handwriting Identification (FLASH ID) is an ongoing research project developed in conjunction with Gannon Technologies Group (now Sciometrics, LLC), George Mason University, and the FBI. This handwriting biometric system will ultimately assist FDEs in the comparison and identification of handwritten documents. Similar in concept to the Automated Fingerprint Identification System (AFIS), FLASH ID automatically compares suspect handwriting against databases of preloaded writers. FLASH ID uses algorithms to automatically segment handwriting into graphical forms called graphemes. The software compares the topology and geometric features of these graphemes and compiles a list of biometric similarity scores for each writing sample in a given database. The sample at the top of this list bears the strongest similarity to the captured specimen.

An additional publication by Christopher P. Saunders, et al. addresses the biometrics of handwriting using automated comparison procedures. Saunders states "Biometric individuality is an important concept to study in relation to the individuality of handwriting because it represents the "best" measure of the degree of individuality possible when using a given comparison procedure."[31] Saunders also states "The proposition that no two individuals have the same writing profile cannot be proven empirically. However, the RMP (random match probability), which can be investigated empirically, provides both a measure of the degree of individuality relative to a specific comparison procedure of two writing samples (the so-called biometric individuality) as well as an upper bound on the underlying degree of individuality of writing profiles (as measured by the rarity of matching profiles). Therefore, although an

[28] Caliguri, M.P. and Mohammed, L.A., *The neuroscience of handwriting: applications for forensic document examination*. Taylor & Francis Group, LLC, 2012.

[29] Plamondon, R., O'Reilly, C., Rémi, C., and Duval, T., *The lognormal handwriter: learning, performing, and declining*, Frontiers in Psychology, 2013, 4: 945.

[30] Purcell, J., Turkeltaub, P., Eden, G., and Rapp, B., *Examining the Central and Peripheral Processes of Written Word Production Through Meta-Analysis*, Frontiers in Psychology, 2011, 2: 239.

[31] Saunders, C., Davis, L., Buscaglia, J., Using Automated Comparisons to Quantify Handwriting Individuality, J Forensic Sci, May, 2011, 56: 3, 685.

empirical study cannot "prove" uniqueness of writing profiles, it potentially can be used to show that the chance of two writers having the same writing profile is very small."[32] Although the Department does not currently use statistical interpretations in rendering handwriting comparison opinions, this research further supports the scientific underpinnings of the individuality of handwriting.

[32] *Id*. at 688.