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Handwriting Examination: Meeting the Challenges of Science and the Law

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Introduction

Handwriting is a complex motor skill that is the combination of sensory, neurological, and physiological impulses. Factors such as visual perception and acuity, comprehension of form, central nervous system pathways, and the anatomy and physiology of the bones and muscles of the hand and arm all combine to produce the desired output (Hilton 1982; Huber 1999).

Most people learn to write by copying letter formations from a copybook at a young age. The ability to reproduce the letter formations varies from one person to the next and is based on each writer's perception of the image and his or her ability (motor skills) to reproduce that visual perception. The act of handwriting is mastered through practice and repetition. Once this occurs, writers focus on the subject matter rather than the physical act of writing and deviate from the copybook forms, interjecting their own individual characteristics. The writing becomes a pattern of subconscious, habitual formations that are repeated from one writing to the next (Hilton 1982; Huber 1999).

The comparison and evaluation of these individual features or habits enable forensic document examiners to identify or exclude, if possible, a known writer as the source for any questioned writing. Lay people may recognize the handwriting of an individual and

differentiate between individuals to some degree; however, they observe only the gross features of the handwriting, such as letter formation, size, or slope of the handwriting. Lay people typically do not consider the subtleties in the writing that may differentiate it from other very similar writing. In contrast, document examiners analyze and can differentiate both the gross features and the less conspicuous elements in the writing.

Handwriting features that examiners evaluate include the size and slope of the writing, pen pressure, pen lifts, the spacing between words and letters, the position of the writing on the baseline (the position of the character in relation to the ruled or imaginary line), height relationships, beginning and ending strokes, and line quality. A writer's identity cannot be established through a single individual feature in the writing. Rather, identity is established through a combination of the significant features between the writings, with no significant differences.

Figure 1 demonstrates the visual similarity of size, slope, and general formation of such letters as the uppercase S and lowercase a, d, e, f, n, and r. However, a more detailed examination reveals inconsistencies between the two writings (see Figure 2), such as the number of strokes used to form the uppercase R (two versus one), the ending stroke on the lowercase y (straight versus curved), the formation of the lowercase v (straight versus curved), and the structure of the number 8 (two circles versus one continuous formation).

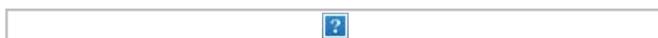


Figure 1: Two handwriting samples that illustrate similarities between them

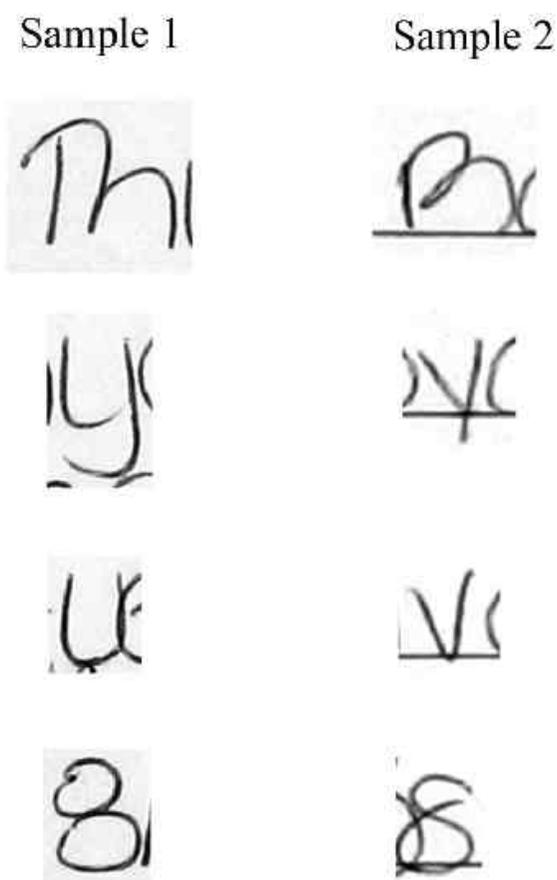


Figure 2: A closer look at the samples from Figure 1 reveals differences between the writing in each sample.

Not all handwriting is identifiable. For example, when a person traces

another individual's signature, that person imitates the writing habits of the original signer, and therefore, the imitator's own handwriting characteristics are not manifested in the tracing. The forensic document examiner would be able to identify the writing as a tracing and associate the writing back to the model signature, if available, but would not be able to identify the writing with the person who traced the signature. Figure 3 illustrates this concept.

In Figure 3, the bottom signature is a tracing of the genuine signature on top, and although they may appear identical, they actually were prepared by two different writers. In fact, the absence of sufficient variation between these two signatures would immediately alert the experienced document examiner to examine the signatures for signs of manipulation, tracing, or simulation.

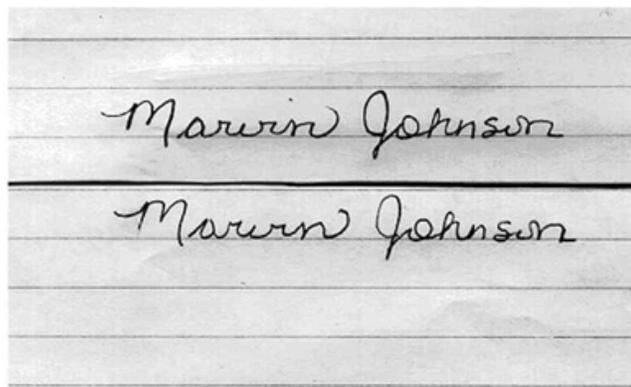


Figure 3: Two signatures prepared by different writers

The Scientific Foundation for Handwriting Analysis

Individuality

The *principle of individuality*, also known as the *principle of uniqueness*, forms the basis for handwriting analysis. That is, no two writers share the same combination of handwriting characteristics given sufficient quantity and quality of writing to compare. Albert S. Osborn (1929) detailed in great length the principle of individuality in the second edition of *Questioned Documents*, stating, "The amount of writing must necessarily always be considered, but total coincidence of all characters is so remote that even identity of a small amount of writing is very improbable." Throughout the 20th century, Livingston (1963), Muehlberger et al. (1977), Huber (1990), Horton (1996), and others conducted small studies that evaluated the frequency of occurrence of handwriting characteristics in order to demonstrate the principle of uniqueness.

Beacom (1960), Gamble (1980), and Boot (1998) 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. Therefore, one would expect the handwriting of twins to be more similar than the writings of any other individuals. In fact, identical twins have been found to share a high degree of similarity in their handwriting. However, these studies, which involved more than 200 sets of twins, all found that trained examiners were able to distinguish between all of the twins' writings.

Finally, anecdotal reports and field screenings by Harvey and Mitchell (1973), Baxendale and Renshaw (1979), Shiver (1996), and others have been useful in demonstrating the principle of uniqueness. These scenarios all involved comparing questioned writing with known writing from between 1000 and 2 million individuals. In each case, examiners identified the writer of the questioned document.

The most famous of these cases was the kidnapping of Peter Weinberger, a one-month-old baby from Long Island, New York. Examiners compared two ransom notes left by the kidnapper with handwriting specimens maintained by the New York State Motor Vehicle Bureau and various federal, state, and local offices. After examining and eliminating more than 2 million samples, examiners identified the writer (Federal Bureau of Investigation n.d.).

In 2002, Dr. Sargur Srihari and colleagues conducted a study to test

the principle of individuality. A sample of 1500 individuals from the general U.S. population was collected and entered into a database. The sample population comprised men and women of different ages and ethnicities. Each individual provided three handwritten samples that captured the various attributes of the written English language such as document structure (e.g., word and line spacing, line skew, margins); positional variations of the letters (i.e., each letter in the initial, middle, and terminal positions of a word); and letter and number combinations (e.g., *ff*, *tt*, *oo*, *00*). A computer software program (CEDAR-FOX) was developed to extract macro-features (slant; word proportion; and measures of pen pressure, writing movement, and stroke formation) from the entire document, from a paragraph in the document, and from a word in the document. It was also used to extract micro-features (gradient, structural, and concavity features) at the character level of the document. Based on only a few macro- and micro-features, Srihari et al. established that the writer of a particular sample can be identified with 98 percent confidence. Inferring these statistics over the entire U.S. population, writer identification can be established with 96 percent confidence. Srihari 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]" (2002).

An additional study by Srihari and colleagues in 2008 further supported the principle of individuality. This study also 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 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.

Variation

No one person writes exactly the same way, even within several repetitions of writings. This is known as natural variation, or intra-writer variation, and represents the second principle of handwriting analysis.

Human beings are not capable of machine-like precision and repetition. As a result of the neuromuscular process, some variation in style (formation) is expected. Variation is an integral part of an individual's writing. It describes the changes and deviations, often minute, that are found in repeated samples of one person's writing. More specifically, variation refers to the different way(s) that a writer makes each letter or character. This variation is normal and serves as an added factor to personalize and individualize writing. As Figure 4 demonstrates, natural variation in an individual's writing prevents superimposed samples by the same individual from aligning perfectly.

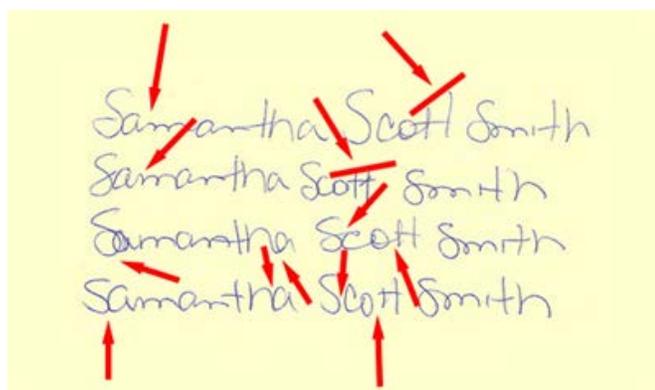


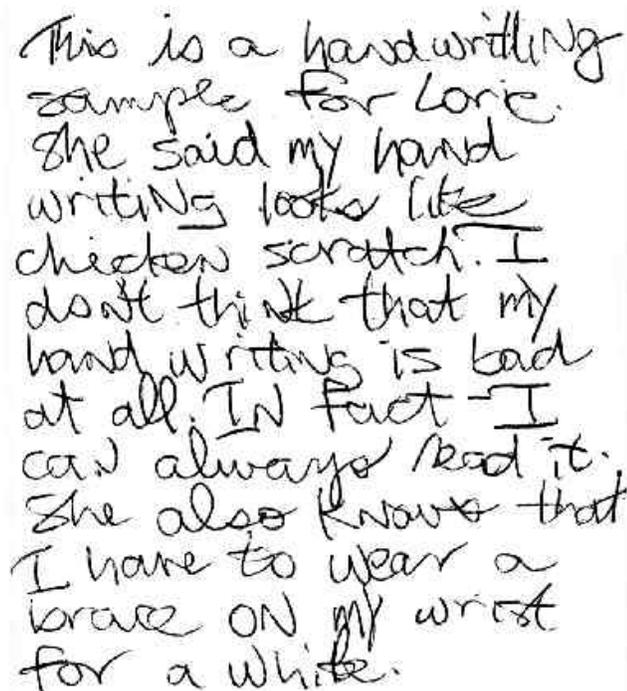
Figure 4: Four signatures written by the same individual, demonstrating variation

In the first two signatures, the initial stroke of the *m* is wider in the first and higher in the second "Samantha." In the word "Scott," the arrows point to the height differences between the two *l*'s. The third and fourth signatures show the spacing differences between the *S* and the *a* and the *h* and the *a* in "Samantha," as well as the differences in connecting strokes between the *S* and the *c* and the *o* and the *t* in the word "Scott."

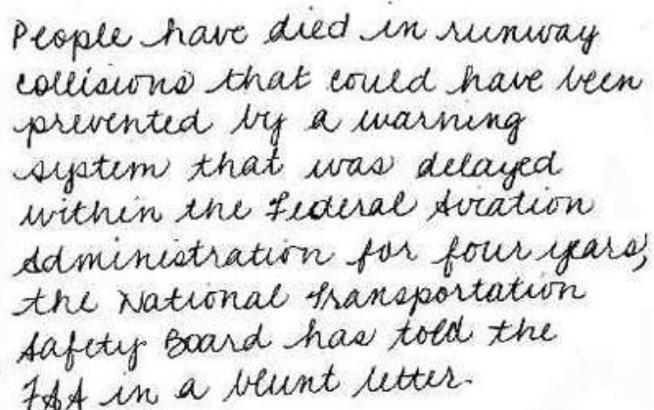
The duration, extent, and speed involved in the coordination of an activity such as handwriting are so complex and may be combined in so many ways that it is virtually impossible to duplicate all parameters exactly. In this way, a variation in performance can and will occur between repetitions of an action by the same person (Rhodes 1978).

Writing Skill

Every writer has a writing skill that cannot be dramatically improved in a short time frame while maintaining all appearances of natural writing. For this reason, the third principle of handwriting analysis is skill level, or the writer's ability to physically reproduce the letter formations they visualize. Skill level is not necessarily related to legibility or an individual's education level. Individuals can write *at or below* their skill level but not *above* their skill level. Figures 5 and 6 show two writing samples prepared by two sisters with a five-year age difference who attended the same schools and grew up in the same environment.



This is a handwriting sample for Lorie. She said my hand writing looks like chicken scratch. I don't think that my hand writing is bad at all. In fact - I can always read it. She also knows that I have to wear a brace ON my wrist for a while.



People have died in runway collisions that could have been prevented by a warning system that was delayed within the Federal Aviation Administration for four years, the National Transportation Safety Board has told the FAA in a blunt letter.

Figure 5 on the top: Low-skilled writer

Figure 6 on the bottom: High-skilled writer

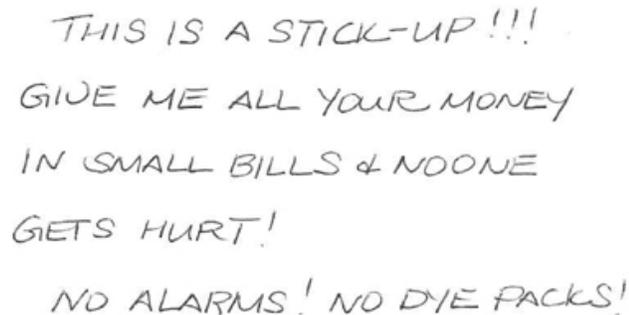
An individual's known writing, including past writings or writings completed during the regular course of business, enable document examiners to assess the individual's skill level and evaluate the skill level as higher or lower than an evidentiary sample. The author of the writing in Figure 6 would have the skill to produce the writing in Figure 5. In contrast, the author of the writing in Figure 5 would not have the skill to produce the writing in Figure 6.

The Methodology of Handwriting Examination

When conducting handwriting examinations (cursive writing, hand printing, signatures, or extended writing) FBI Laboratory personnel use a four-step process (ASTM International 2007; Federal Bureau of Investigation 2007). The following sections describe the steps in the process.

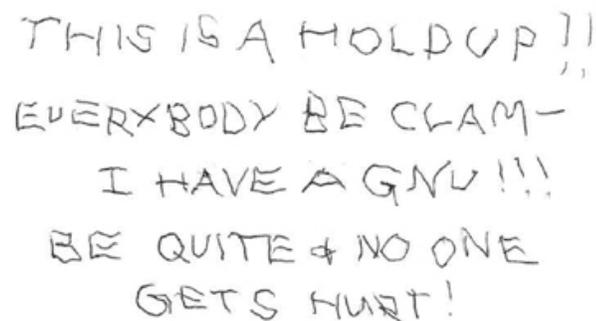
Each analysis begins with an independent examination of the questioned and then the known writing using proper lighting and magnification to determine if the writing is original writing (e.g., ink on paper) and whether it exhibits the characteristics of freely and naturally prepared writing. Some of the characteristics of naturally prepared writing include consistent slant and size, thickening and thinning of the lines as the writing instrument changes direction, and tapered beginning and ending strokes that occur once the writing instrument comes into contact with or leaves the paper. 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.

Figure 7 demonstrates the appearance of naturally prepared writing represented by smooth line quality, tapered beginning and ending strokes, variation in line width, and consistent slant.



THIS IS A STICK-UP !!!
GIVE ME ALL YOUR MONEY
IN SMALL BILLS & NO ONE
GETS HURT!
NO ALARMS! NO DYE PACKS!

Figure 7: A bank-robbery note illustrating naturally prepared writing



THIS IS A HOLDUP!!
EVERYBODY BE CLAM-
I HAVE A GUN!!!
BE QUIET & NO ONE
GETS HURT!

Figure 8: A bank-robbery note illustrating distorted writing

Once a document examiner 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 examiner observes the numerous features exhibited in the bodies of writing to determine if significant similarities or differences exist. Every document examiner at the FBI Laboratory completes a two-year training program that includes classroom lectures, practical problems, oral boards, testing, and moot courts. This training provides the fundamental knowledge for examiners to understand the significance of the observed characteristics. Examiners also rely on their ability to discern minute form differences. This ability 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 examiner's ability to distinguish minute differences in forms, angles, and sizes (Osborn 1975).

The characteristics examiners 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 document examiner does not consider misspellings as individualizing characteristics of the handwriting.

The following excerpt from ASTM Guide E 2290 (2007) illustrates the extensive list of features document examiners consider during the examination process.

"Among the features to be considered by the examiner are elements of the writing such as abbreviation; alignment; arrangement, formatting, and positioning; capitalization; connectedness and disconnectedness; cross strokes and dots, diacritics and punctuation; direction of strokes; disguise; embellishments; formation; freedom of execution; handedness; legibility; line quality; method of production; pen hold and pen position; overall pressure and patterns of pressure; emphasis; proportion; simplification; size; skill; slant or slope; spacing; speed; initial, connecting, and terminal strokes; system; tremor; type of writing; and range of variation. Other features such as lifts, stops and hesitations of the writing instrument; patching and retouching; slow, drawn quality of the line; unnatural tremor; and guide lines of various forms should be looked for and considered when present. Potential limiting factors such as age; illness or injury; medication, drugs or alcohol (intoxication or withdrawal); awkward writing position; cold or heat; fatigue; haste or carelessness; nervousness; nature of the document; use of the unaccustomed hand; [and] deliberate attempt at disguise or auto-forgery should be considered" (ASTM 2007) because they may not represent the natural handwriting of the individual.

Figure 9 demonstrates some of the characteristics evaluated during an examination. Number 1 demonstrates how the uppercase *I* sits below the ruled line. Number 2 shows the connecting stroke between

the *s* and *t*. Number 3 demonstrates how the *N* is higher than the *g*. Number 4 shows the larger size of the *N* when compared to the adjacent letters.

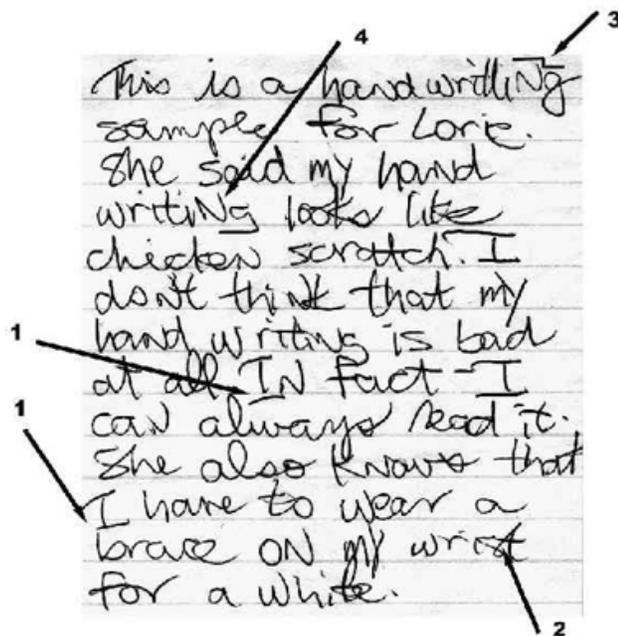


Figure 9: The handwriting sample from Figure 5, illustrating 1, baseline; 2, connecting stroke; 3, height relationships; 4, size

The next step in the methodology involves evaluating the significance of the nature and combination of the characteristics observed during the comparison process. This evaluation is based on the examiner's training, knowledge, and experience. To identify a body of writing with a particular writer, the examiner must find significant characteristics in common between the questioned and known writing, while observing no significant differences. Each characteristic may not be unique when considered individually, but when coupled with other observed characteristics, the writing is then considered unique to a particular writer. To eliminate a writer as having prepared a questioned writing, an examiner must observe significant differences between the questioned and known writing.

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 include evaluation of photocopied specimens, which yield poor detail and clarity and prevent the examiner from properly assessing line quality, connecting strokes, letter formations, and beginning and ending strokes; 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; 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.

Although examiners may not be able to associate a handwriting sample with a specific individual, they can sometimes determine the origin or authenticity of the writing. However, handwriting examinations cannot determine such traits as age, sex, personality, or intent (ASTM 2007).

The final step in the examination process is verification. In this step, another qualified examiner evaluates the writing submitted for comparison using the methodology previously described. In the FBI Laboratory Questioned Documents Unit (QDU), 100 percent of the cases are peer-reviewed by another qualified examiner. QDU examiners also conduct blind reviews in cases meeting previously established criteria.

Conclusions Reached During Handwriting Examinations

The FBI Laboratory has not established a specific number of “points” or characteristics needed to identify a questioned writing as having been prepared by a particular individual. In order for a forensic document examiner to identify an individual as having prepared a questioned writing, agreement must exist between significant characteristics in the questioned and known writing with no significant differences. The examiner must explain any exceptions.

The FBI Laboratory’s Questioned Documents Unit uses the following conclusions in handwriting comparisons:

- **Identification**—A determination that the questioned and known writings were prepared by the same writer because of agreement in individualizing characteristics. No differences are present, except for normal variation. Unexplained variations or characteristics are far outweighed by the combined effect of agreement in all other details. No significant limitations are present. Typical wording for this conclusion in an FBI Laboratory report would be: “It was determined that the questioned writing on specimen Q1 was prepared by John Doe, the writer of K1.”
- **May Have (Qualified Opinion)**—Indications that specimens being compared were prepared by the same writer. The conclusion is based on the prevalence of characteristics in common between the specimens being compared. However, some doubt or lack of agreement in detail is observed, usually because of some limitation or the presence of characteristics observed in the questioned writing that could not be explained on the basis of the available known writing. Typical wording for this conclusion in an FBI Laboratory report would be: “A definite determination could not be reached as to whether the questioned writing on specimen Q1 was prepared by John Doe, the writer of K1, due to [list limiting factors]. However, handwriting characteristics in common were observed that indicate that John Doe, K1, may have prepared the questioned writing on specimen Q1.”
- **No Conclusion**—Cannot determine whether the specimens being compared were prepared by the same writer, usually because of such factors as lack of comparability or lack of clarity and detail in the submitted specimens, which may significantly limit meaningful examinations. In instances when meaningful examinations can be conducted, the weight of the combination of characteristics observed in common is counterbalanced by the weight of the combination of inconsistencies or unexplained characteristics observed. Typical wording for this conclusion in an FBI Laboratory report would be: “It could not be determined whether the questioned writing on specimen Q1 was prepared by John Doe, the writer of K1, due to [list limiting factors].”
- **May Not Have (Qualified Opinion)**—Indications that the specimens being compared were not prepared by the same writer. This conclusion is based on the prevalence of dissimilarities between the specimens being compared. However, some uncertainty remains, usually because of some limitation, the presence of some significant characteristics in common, or the presence of inconsistencies or characteristics observed in the questioned writing that could not be explained

as differences based on the available known writing. Typical wording for this conclusion in an FBI Laboratory report would be: "A definite determination could not be reached as to whether the questioned writing on specimen Q1 was prepared by John Doe, the writer of K1, due to [list limiting factors]. However, handwriting inconsistencies were observed that indicate that John Doe, K1, may not have prepared the questioned writing on specimen Q1."

- Elimination**—A determination that the questioned and known writing were not prepared by the same writer because of sufficient disagreement in individual characteristics. Differences are observed. Any limited similarities are far outweighed by the combined effect of sufficient disagreement in all other details. No significant limitations are present. Typical wording for this conclusion in an FBI Laboratory report would be: "It was determined that the questioned writing on specimen Q1 was not prepared by John Doe, the writer of K1."

In the samples of writing in Figure 10, the baseline of the uppercase *I*, the connecting stroke between the *S* and the *h*, the height of the *k* in relation to adjacent letters in the word, and the structural differences in the *g*, *r*, and *t* are consistently different between the writings, thus illustrating an elimination conclusion.



Figure 10: The handwriting sample from Figure 5, along with a comparison sample from a different writer, illustrating an elimination conclusion. The number 1s point to baseline alignment; number 2s, the connecting strokes; number 3s, height relationships; and number 4s, structural differences.

Standards

The Technical Working Group for Documents, now the Scientific Working Group for Questioned Documents (SWGDOC), was formed in 1997 to address the need for standards in the forensic document community. SWGDOC's technical experts produce standards and submit them to ASTM International for ballot and eventual publication. ASTM is a voluntary standards development organization for technical standards for materials, products, systems, and services. The ASTM Committee E30 on Forensic Science was established in 1970 and consists of 10 technical subcommittees, one of which is the E30.02 Committee on Questioned Documents. Each standard submitted to ASTM is subjected to a rigorous review process by

forensic document examiners and other forensic practitioners, as well as individuals with a general interest in the discipline. This review process ensures clear, concise, and high-quality standards.

To date, the forensic document discipline has published the following 18 standards through ASTM (see <http://www.ASTM.org>). The two-digit number following the hyphen indicates the date of the standard and, as of this writing, is the most current standard available.

- *E444-09 Standard Guide for Scope of Work of Forensic Document Examiners.*
- *E1422-05 Standard Guide for Test Methods for Forensic Writing Ink Comparison.*
- *E1658-08 Standard Terminology for Expressing Conclusions of Forensic Document Examiners.*
- *E1789-04 Standard Guide for Writing Ink Identification.*
- *E2195-02 Standard Terminology Relating to the Examination of Questioned Documents.*
- *E2285-08 Standard Guide for Examination of Mechanical Checkwriter Impressions.*
- *E2286-08a Standard Guide for Examination of Dry Seal Impressions.*
- *E2287-09 Standard Guide for Examination of Fracture Patterns and Paper Fiber Impressions on Single-Strike Film Ribbons and Typed Text.*
- *E2288-09a Standard Guide for Physical Match of Paper Cuts, Tears, and Perforations in Forensic Document Examinations.*
- *E2289-08 Standard Guide for Examination of Rubber Stamp Impressions.*
- *E2290-07a Standard Guide for Examination of Handwritten Items.*
- *E2291-03 Standard Guide for Indentation Examinations.*
- *E2325-05 Standard Guide for Non-destructive Examination of Paper.*
- *E2331-04 Standard Guide for Examination of Altered Documents.*
- *E2388-05 Standard Guide for Minimum Training Requirements for Forensic Document Examiners.*
- *E2389-05 Standard Guide for Examination of Documents Produced with Liquid Ink Jet Technology.*
- *E2390-06 Standard Guide for Examination of Documents Produced with Toner Technology.*
- *E2494-08 Standard Guide for Examination of Typewritten Items.*

Additionally, standards that have been submitted to ASTM for ballot and publication include:

- Standard Guide for the Preservation of Charred Documents.
- Standard Guide for the Preservation of Liquid-Soaked Documents.
- Standard Guide for Examination of Handwritten Items for Simulation and Tracing.
- Standard Guide for Classification of Facsimile Devices using Transmitting Terminal Identifier/Receiving Terminal Identifier (TTI/RTI).
- Financial and Identification Documents.
- Case Review.

Conclusion

As a discipline routinely accepted under *Frye* (*Frye v. United States*, 54 App. D.C. 46, 293 F. 1013, 1014 [1923]), forensic document examination has been consistently accepted in the courts in spite of the challenges generated by the *Daubert* decision in 1993 (*Daubert v. Merrell Dow Pharmaceuticals*, 509 U.S. 579 [1993]). Published research demonstrates the validity of the expertise and supports the principle of handwriting individuality. Published standards ensure consistency in methodology. Document examiners in both public (local, state, federal, and international) and private laboratories use these standards. Ongoing academic research continues to support the forensic document examination community in strengthening the scientific basis for handwriting comparison.

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References

- ASTM International. *E2290-07a Standard Guide for Examination of Handwritten Items*. ASTM International, West Conshohocken, Pennsylvania, 2007. Available:
<http://www.astm.org/Standards/E2290.htm>.
- Baker, J. N. *Law of Disputed and Forged Documents*. Michie, Charlottesville, Virginia, 1955, p. 57 58.
- Baxendale, D. and Renshaw, I. D. The large-scale searching of handwriting samples, *Journal of the Forensic Science Society* (1979) 19:245 251.
- Beacom, M. S. A study of handwriting by twins and other persons of multiple births, *Journal of Forensic Sciences* (1960) 5:121 131.
- 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.
- Byrd, J. S. and Bertram, D. Form-blindness, *Journal of Forensic Identification* (2003) 53:315 341.
- Evelt, I. W. and Totty, R. N. A study of the variation in the dimensions of genuine signatures, *Journal of the Forensic Science Society* (1985) 25:207 215.
- Federal Bureau of Investigation. Famous cases: The Weinberger kidnapping, *FBI History* [Online]. (n.d.). Available:
<http://www.fbi.gov/libref/historic/famcases/weinber/weinbernew.htm>. Accessed August 25, 2009.
- Federal Bureau of Investigation. Laboratory Division. *Questioned Documents Unit Protocols*. FBI Laboratory, Quantico, Virginia, 2007.

- Gamble, D. The handwriting of identical twins, *Canadian Society of Forensic Science Journal* (1980) 13:11–30.
- Harvey, R. and Mitchell, R. M. The Nicola Brazier murder: The role of handwriting in a large-scale investigation, *Journal of the Forensic Science Society* (1973) 13:157–168.
- Hilton, O. *Scientific Examination of Questioned Documents*. Elsevier, New York, 1982, pp. 10, 17, 153–157, 174.
- 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.
- Huber, R. A. *The Uniqueness of Writing*. Presented at the American Society of Questioned Document Examiners annual meeting, San Jose, California, 1990.
- Huber, R. A. and Headrick A. M. *Handwriting Identification: Facts and Fundamentals*. CRC Press-Taylor & Francis, Boca Raton, Florida, 1999, pp. 10–14.
- Inman, K. and Rudin, N. *Principles and Practice of Criminalistics: The Profession of Forensic Science*. CRC Press-Taylor & Francis, Boca Raton, Florida, 2001, pp. 123–125.
- Keele, S. W. Movement control in skilled motor performance, *Psychological Bulletin* (1968) 70:387–403.
- Livingston, O. B. Frequency of certain characteristics in handwriting, pen-printing of two hundred people, *Journal of Forensic Sciences* (1963) 8:250–258.
- Muehlberger, R. J., Newman, K. W., Regent, J., and Wichmann, J. G. A statistical examination of selected handwriting characteristics, *Journal of Forensic Sciences* (1977) 22:206–215.
- Osborn, A. S. *Questioned Documents*. 2nd ed. Nelson-Hall, Chicago, 1929, pp. 205–216, 226–233, 247–248, 363–376.
- Osborn, A. S. *The Problem of Proof*. 2nd ed. Nelson-Hall, Chicago, Illinois, 1975, pp. 491–501.
- Purdy, D. C. Identification of handwriting. In: *Scientific Examination of Questioned Documents*. 2nd ed. J. S. Kelly and B. S. Lindblom, Eds. CRC Press-Taylor & Francis, Boca Raton, Florida, 2006, p. 47–74.
- Rhodes, E. F. *The implications of kinesthetic factors in forensic handwriting comparisons*, Doctoral thesis, University of California at Berkeley, 1978.
- Shiver, F. C. *Case Report: The Individuality of Handwriting Demonstrated Through the Field Screening of 1000 Writers*. Presented at the American Society of Questioned Document Examiners annual meeting, Washington, D.C., 1996.
- Srihari, S. N., Cha, S.-H., Arora, H., and Lee, S. Individuality of handwriting, *Journal of Forensic Sciences* (2002) 47:856–872.
- Srihari, S., Huang, C., and Srinivasan, H. On the discriminability of the handwriting of twins, *Journal of Forensic Sciences* (2008) 53:430–446.

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