chapter 16

Document and Voice Examination

Key Terms

charred document

erasure

exemplar

indented writings

infrared luminescence

natural variations

obliteration

questioned document

voiceprint

Learning Objectives

After studying this chapter you should be able to:

- Define the term *questioned document*
- Know what common individual characteristics are associated with handwriting
- List some important guidelines for the collection of known writings for comparison to a questioned document

- Recognize some of the class and individual characteristics of printers and photocopiers
- List some of the techniques document examiners use to uncover alterations, erasures, obliterations, and variations in pen inks
- Recognize the three parameters of speech that a voiceprint represents

The Unabomber

In 1978, a parcel addressed to a Northwestern University professor exploded as it was being opened by a campus security officer. This was the first of a series of bomb-containing packages sent to universities and airlines. The perpetrator was dubbed UN (university) A (airlines) BOM; hence, *the Unabomber*. The explosives were usually housed in a pipe within a wooden box. The explosive ingredients generally were black powder, smokeless powder, or an ammonium nitrate mix. The box was filled with metal objects to create a shrapnel effect on explosion. The device typically had the initials "FC" punched into it. The first Unabomber fatality came in 1985. The Unabomber surfaced again in 1993, mailing bombs to two university professors. Their injuries were not fatal, but his next two attacks did result in fatalities.

In 1995, the case took an unexpected turn when the Unabomber promised to end his mad spree if his 35,000-page typewritten "Manifesto" sent to the *New York Times* and *The Washington Post* were published. The *Manifesto* proved to be a long, rambling rant against technology, but it offered valuable clues that broke the case. David Kaczynski realized that the *Manifesto's* writing style and the philosophy it espoused closely resembled that of his brother Ted. Linguistic experts carefully pored over the *Manifesto's* content. Ted Kaczynski was arrested in Montana in 1996. Inside his ramshackle cabin were writings similar to

the *Manifesto,* three manual typewriters, and bomb-making materials. Forensic document examiners matched the typewritten *Manifesto* to one of the typewriters recovered from the cabin.

Ordinarily, the work of the document examiner involves examining of handwriting and typescript to ascertain the source or authenticity of a questioned document. However, document examination is not restricted to a mere visual comparison of words and letters. The document examiner must know how to use the techniques of microscopy, photography, and even such analytical methods as chromatography to uncover successfully all efforts, both brazen and subtle, designed to change the content or meaning of a document. Alterations of documents through overwriting, erasures, or the more obvious crossing out of words must be recognized and characterized as efforts to alter or obscure the original meaning of a document. The document examiner uses his or her special skills to reconstruct the written contents of charred or burned paper or to uncover the meaning of indented writings found on a paper pad after the top sheet has been removed.

Any object that contains handwritten or typewritten markings whose source or authenticity is in doubt may be referred to as a **questioned document**. Such a broad definition covers all of the written and printed materials we normally encounter in our daily social and business activities. Letters, checks, drivers' licenses, contracts, wills, voter registrations, passports, petitions, and even lottery tickets are the more common specimens received in crime laboratories to be examined. However, we need not restrict our examples to paper documents. Questioned documents may include writings or other markings found on walls, windows, doors, or any other objects.

Document examiners possess no mystical powers or scientific formulas for identifying the authors of writings. They apply knowledge gathered through years of training and experience to

recognize and compare the individual characteristics of questioned and known authentic writings. For this purpose, the gathering of documents of known authorship or origin is critical to the outcome of the examination. Collecting known writings may entail considerable time and effort, and their collection may be further hampered by uncooperative or missing witnesses. However, the uniqueness of handwriting makes this type of physical evidence, like fingerprints, one of few definitive individual characteristics available to the investigator, a fact that certainly justifies an extensive investigative effort.

HANDWRITING COMPARISONS

Document experts continually testify that no two individuals write exactly alike. This is not to say that there cannot be marked resemblances between two individuals' handwritings, because many factors make up the total character of a person's writing. Perhaps the most obvious feature of handwriting to the layperson is its general style. As children we all learn to write by attempting to copy letters that match a standard form or style shown to us by our teachers. The style of writing acquired by the learner is that which is fashionable for the particular time and locale. In the United States, for example, the two most widely used systems are the Palmer method, first introduced in 1880, and the Zaner-Blosser method, introduced in about 1895. To some extent, both of these systems are taught in nearly all fifty states.

The early stages that accompany the learning and practicing of handwriting are characterized by a conscious effort on the part of the student to copy standard letter forms. It is not surprising that many pupils in a handwriting class tend at first to have writing styles that are similar to one another, with minor differences attributable to skill in copying. However, as initial writing skills improve, a child normally reaches the stage where the nerve and motor responses associated with

the act of writing become subconscious. The individual's writing now begins to take on innumerable habitual shapes and patterns that distinguish it from all others. The document examiner looks for these unique writing traits.

The unconscious handwriting of two different individuals can never be identical. Individual variations associated with mechanical, physical, and mental functions make it extremely unlikely that all of these factors can be exactly reproduced by any two people. Thus, variations are expected in angularity, slope, speed, pressure, letter and word spacings, relative dimensions of letters, connections, pen movement, writing skill, and finger dexterity. Furthermore, many other factors besides pure handwriting characteristics should be considered. The arrangement of the writing on the paper may be as distinctive as the writing itself. Margins, spacings, crowding, insertions, and alignment are all results of personal habits. Spelling, punctuation, phraseology, and grammar can be personal and, if so, combine to individualize the writer.

In a problem involving the authorship of handwriting, all characteristics of both the known and questioned documents must be considered and compared. Dissimilarities between the two writings are a strong indication of two writers, unless these differences can logically be accounted for by the facts surrounding the preparation of the documents. Because any single characteristic, even the most distinctive one, may be found in the handwriting of other individuals, no single handwriting characteristic can by itself be taken as the basis for a positive comparison. The final conclusion must be based on a sufficient number of common characteristics between the known and questioned writings to effectively preclude the chance of their having originated from two different sources.

What constitutes a sufficient number of personal characteristics? Here again, there are no hard-and-fast rules for making such a determination. The expert examiner can make this judg-

ment only in the context of each particular case.

When the examiner receives a reasonable amount of known handwriting for comparison, there is usually little difficulty in finding sufficient evidence to determine the source of a questioned document. Frequently, however, circumstances may prevent a positive conclusion or may permit only the expression of a qualified opinion. Such situations usually develop when an insufficient number of known writings are made available for comparison. Although nothing may be found that definitely points to the questioned and known handwriting being of a different origin, not enough personal characteristics may be present in the known writings that are consistent with the questioned materials.

Difficulties may also arise when the examiner receives questioned writings containing only a few words, all deliberately written in a crude, unnatural form or all very carefully written and thought out so as to disguise the writer's natural style—a situation usually encountered with threatening or obscene letters. It is extremely difficult to compare handwriting that has been very carefully prepared to a document written with such little thought for structural details that it contains only the subconscious writing habits of the writer. However, although it may be relatively easy to change one's writing habits for a few words or sentences, the task of maintaining such an effort grows more difficult with each additional word. When an adequate amount of writing is available to the examiner, the attempt at total disguise may fail. This was illustrated in the attempt by Clifford Irving to forge letters in the name of the late industrialist Howard Hughes in order to obtain lucrative publishing contracts for Hughes's life story. Figure 16–1 shows the forged signatures of Howard Hughes along with Clifford Irving's known writings. By comparing these signatures, document examiner R. A. Cabbane of the U.S. Postal Inspection Service detected many examples of Irving's personal characteristics in the forged signatures. For example,

note the formation of the letter *r* in the word *Howard* on lines 1 and 3, as compared with the composite on line 6. Observe the manner in which the terminal stroke of the letter *r* tends to terminate with a little curve at the baseline of Irving's writing and the forgery. Notice the way the bridge of the *w* drops in line 1 and also in line 6. Also, observe the similarity in the formation of the letter *g* as it appears on line 1 as compared with the second signature on line 5.

The document examiner must also be aware that writing habits may be altered beyond recognition by the influence of drugs or alcohol. Under these circumstances, it may be impossible to obtain known writings of a suspect written under conditions comparable to those at the time the questioned document was prepared.

COLLECTION OF HANDWRITING EXEMPLARS

It should be fairly obvious by now that collection of an adequate number of known writings (**exemplars**) is most critical for determining the outcome of a comparison. Generally, known writings of the suspect furnished to the examiner should be as similar as possible to the questioned document. This is especially true with respect to the writing implement and paper. Styles and habits may be somewhat altered if a person switches from a pencil to a ballpoint pen or to a fountain pen. The way the paper is ruled, or the fact that it is unruled, may also affect the handwriting of a person who has become particularly accustomed to one type or the other. Known writings should also contain some of the words and combinations of letters present in the questioned document.

The known writings must be adequate in number to show the examiner the range of **natural variations** in a suspect's writing characteristics. No two specimens of writing prepared by one person are ever identical in every detail. Variation is an inherent part of natural writing. In fact, a

signature forged by tracing an authentic signature can often be detected even if the original and tracing coincide exactly, because no one ever signs two signatures exactly alike.

Many sources are available to the investigator for establishing the authenticity of the writings of a suspect. An important consideration in selecting sample writings is the age of the genuine document relative to the questioned one. It is important to try to find standards that date closely in time to the questioned document. For most typical adults, basic writing changes are comparatively slow. Therefore, material written within two or three years of the disputed writing is usually satisfactory for comparison; as the age difference between the genuine and unknown specimens becomes greater, the standard tends to become less representative.

Despite the many potential sources of handwriting exemplars, it may be difficult or impossible to obtain an adequate set of collected standards. In these situations, handwriting may have to be obtained voluntarily or under court order from the suspect. There is ample case law to support the constitutionality of taking handwriting specimens. In the case of *Gilbert* v. *California,*[1] the Supreme Court upheld the taking of handwriting exemplars before the appointment of counsel. The Court also reasoned that handwriting samples are identifying physical characteristics that lie outside the protection privileges of the Fifth Amendment. Furthermore, in the case of *United States* v. *Mara,*[2] the Supreme Court ruled that taking a handwriting sample did not constitute an unreasonable search and seizure of a person and hence did not violate Fourth Amendment rights.

As opposed to nonrequested specimens (written without the thought that they may someday be used in a police investigation), requested writing samples may be consciously altered by the writer. However, the investigator can take certain steps to minimize attempts at deception. The requirement of several pages of writing normally provides enough material that is free of attempts at deliberate disguise or nervousness for a valid comparison. In addition, the writing of

dictation yields exemplars that best represent the suspect's subconscious style and characteristics.

Other steps that can be taken to minimize a conscious writing effort, as well as to ensure conditions approximating those of the questioned writing, can be summarized as follows:

1. The writer should be allowed to write sitting comfortably at a desk or table and without distraction.
2. The suspect should not under any conditions be shown the questioned document or be told how to spell certain words or what punctuation to use.
3. The suspect should be furnished a pen and paper similar to those used in the questioned document.
4. The dictated text should be the same as the contents of the questioned document, or at least should contain many of the same words, phrases, and letter combinations found in the document. In handprinting cases, the suspect must not be told whether to use uppercase (capital) or lowercase (small) lettering. If after writing several pages the writer fails to use the desired type of lettering, he or she can then be instructed to include it. Altogether, the text must be no shorter than a page.
5. Dictation of the text should take place at least three times. If the writer is trying to disguise the writing, noticeable variations should appear among the three repetitions. Discovering this, the investigator must insist on continued repetitive dictation of the text.
6. Signature exemplars can best be obtained when the suspect is required to combine other writings with a signature. For example, instead of compiling a set of signatures alone, the writer might be asked to fill out completely twenty to thirty separate checks or receipts, each of

which includes a signature.

7. Before requested exemplars are taken from the suspect, a document examiner should be consulted and shown the questioned specimens.

TYPESCRIPT COMPARISONS

One mechanical writing device the document examiner encounters is the typewriter, although it is not as prevalent as it used to be. Examiners are most often asked the following two questions about typewriters: (1) Can the make and model of the typewriter used to type the questioned document be identified? (2) Can a particular suspect typewriter be identified as having prepared the questioned document?

To answer the first question, the examiner must have access to a complete reference collection of past and present typefaces used by typewriter manufacturers. The two most popular typeface sizes are pica (10 letters to the inch) and elite (12 letters to the inch). Although a dozen manufacturers may use a pica or an elite typeface, many of these are readily distinguishable when the individual type character's style, shape, and size are compared.

As is true for any mechanical device, use of a typewriter will result in wear and damage to the machine's moving parts. These changes occur both randomly and irregularly, thereby imparting individual characteristics to the typewriter. Variations in vertical and horizontal alignment (characters are too high or low or too far left or right of their correct position) and perpendicular misalignment of characters (characters leaning to the left or to the right), as well as defects in each typeface, are most valuable for proving the identity of a typewriter (see Figure 16–2).

The widespread use of business and personal computers is creating a series of new problems to challenge the skills of the document examiner. Personal computers use daisy wheel, dot-

matrix, ink-jet, and laser printers. More and more, the document examiner encounters problems involving these machines, which often produce typed copies that have only inconspicuous defects.

Associating a particular typewriter with a typewritten document requires comparing the questioned document to exemplars prepared from the suspect typewriter. As with handwriting, collection of proper standards is the foundation of such comparisons. In this respect, it is preferable if the investigator can directly supply the document examiner with the questioned typewriter. This arrangement gives the examiner the opportunity to prepare an adequate number of exemplars and also allows direct examination of the machine's typefaces. If the investigator has to prepare standards from the questioned machine, a minimum of one copy in full word-for-word order of the questioned typewriting must be obtained.

Another area of investigation relates to the ribbon. An examination of the type impressions left on a ribbon may reveal the portion of the ribbon on which a particular text was typed.

When the suspect typewriter is not available for examination, the investigator must gather known writings that have been typed on the suspect machine. Ideally, material should be selected that contains many of the same combinations of letters and words found on the questioned document. The individual defects that characterize a typewriter develop and change as the machine is used; some may have changed between the preparation of the questioned and standard material. Hence, if many specimens are available, those prepared near the time of the disputed document should be collected.

PHOTOCOPIER, PRINTER, AND FAX EXAMINATION

With the emergence of digital technology, document examiners are confronted with a new array

of machines capable of creating documents subject to alteration or fraudulent use. In the cases of photocopiers, fax machines, and computer printers, an examiner may need to identify the make and model of a machine that may have been used in printing a document. Alternatively, the examiner may need to compare a questioned document with test samples printed from a suspect machine. Typically, the examiner generates approximately ten samples through each machine to obtain a sufficient representation of a photocopier's characters. A side-by-side comparison is then made between the questioned document and the printed exemplars to compare markings produced by the machine.

Transitory defect marks originating from random debris on the glass platen, inner cover, or mechanical portions of a copier produce images. These images are often irregularly shaped and sometimes form distinctive patterns. Thus, they become points of comparison as the document examiner attempts to link the document to suspect copiers. The gradual change, shift, or duplication of these marks may aid the examiner in dating the document.

In analyzing computer printouts and faxes, examiners use the same approach for comparing the markings on a questioned document to exemplar documents generated by a suspect machine. These markings include all possible transitory patterns arising from debris and other extraneous materials. Interestingly, fax machines print a header known as the *transmitting terminal identifier* (TTI) at the top of each fax page. For the document examiner, the TTI is a very important point of comparison. The header and the document's text should have different type styles. TTIs can be fraudulently prepared and placed in the appropriate position on a fax copy. However, a microscopic examination of the TTI's print quickly reveals significant characteristics that distinguish it from a genuine TTI. In determining the fax machine's model type, the examiner most often begins by analyzing the TTI type style. The fonts of that line are determined by the sending

machine. The number of characters, their style, and their position in the header are best evaluated through a collection of TTI fonts organized into a useful database. One such database is maintained by the American Society of Questioned Document Examiners.

When the suspect machine is not available, the examiner may need to analyze the document's class characteristics to identify the make and model of the machine. It is important to identify the printing technology, the type of paper, the type of toner or ink used, the chemical composition of the toner, and the type of toner-to-paper fusing method used in producing the document. Examination of the toner usually involves microscopic analysis to characterize its surface morphology, followed by identification of the inorganic and organic components of the toner. These results separate model types into categories based on their mechanical and printing characteristics. Typically, document examiners access databases to help identify the model type of machine used to prepare a questioned document. The resulting list of possibilities produced by the database hopefully reduces the number of potential machines to a manageable number. Obviously, once a suspect machine is identified, the examiner must perform a side-by-side comparison of questioned and exemplar printouts as described previously.

Computer printer model determination requires an extensive analysis of the specific printer technology and type of ink used. Visual and microscopic techniques provide useful information in determining the technology and toner used. Generally, printers are categorized as impact and nonimpact printers by the mechanism of their toner application. Nonimpact printers, such as ink-jet and laser printers, and impact printers, such as thermal and dot-matrix printers, all have characteristic ways of printing documents. Character shapes, toner differentiation, and toner application methods are easily determined with a low-power microscope and help the examiner narrow the possibilities of model type.

ALTERATIONS, ERASURES, AND OBLITERATIONS

Documents are often altered or changed after preparation so that their original intent may be hidden or so that a forgery may be perpetrated. Documents can be changed in several ways, and for each way, the application of a special discovery technique is necessary.

One of the most common ways to alter a document is to try to erase parts of it, using an India rubber eraser, sandpaper, razor blade, or knife to remove writing or type by abrading or scratching the paper's surface. All such attempts at erasure disturb the upper fibers of the paper. These changes are apparent when the suspect area is examined under a microscope using direct light or by allowing the light to strike the paper obliquely from one side (side lighting). Although microscopy may reveal whether an **erasure** has been made, it does not necessarily indicate the original letters or words present. Sometimes so much of the paper has been removed that identifying the original contents is impossible.

In addition to abrading the paper, the perpetrator may also choose to obliterate words with a chemical erasure. In this case, strong oxidizing agents are placed over the ink, producing a colorless reaction product. Although such an attempt may not be noticeable to the naked eye, examination under the microscope reveals a discoloration on the treated area of the paper. Sometimes examination of the document under ultraviolet or infrared lighting reveals the chemically treated portion of the paper. Interestingly, examination of documents under ultraviolet light may also reveal the presence of fluorescent ink markings that go unnoticed in room light, as seen in Figure 16–3.

Some inks, when exposed to blue-green light, absorb the radiation and reradiate infrared light. This phenomenon is known as **infrared luminescence**. Thus, if an alteration is made to a

document with ink differing from the original, it can sometimes be detected by illuminating the document with blue-green light and using infrared-sensitive film to record the light emanating from the document's surface. In this fashion, any differences in the luminescent properties of the inks are observed (see Figure 16–4). Infrared luminescence has also revealed writing that has been erased. Such writings may be recorded by invisible residues of the original ink that remain embedded in the paper even after an erasure.

Another important application of infrared photography arises from the observation that inks may differ in their ability to absorb infrared light. Thus, illuminating a document with infrared light and recording the light reflected off the document's surface with infrared-sensitive film may enable the examiner to differentiate inks of a dissimilar chemical composition (see Figure 16–5).

Intentional **obliteration** of writing by overwriting or crossing out is seldom used for fraudulent purposes because of its obviousness. Nevertheless, such cases may be encountered in all types of documents. Success at permanently hiding the original writing depends on the material used to cover the writing. If it is done with the same ink as was used to write the original material, recovery will be difficult if not impossible. However, if the two inks are of a different chemical composition, photography with infrared-sensitive film may reveal the original writing. Infrared radiation may pass through the upper layer of writing while being absorbed by the underlying area (see Figure 16–6).

Close examination of a questioned document sometimes reveals crossing strokes or strokes across folds of perforations in the paper that are not in a sequence that is consistent with the natural preparation of the document. Again, these differences can be shown by microscopic or photographic scrutiny.

Infrared photography sometimes reveals the contents of a document that has been accidentally or purposely charred in a fire. Another way to decipher **charred documents** involves reflecting light off the paper's surface at different angles in order to contrast the writing against the charred background (see Figure 16–7).

Digital image processing is the method by which the visual quality of digital pictures is improved or enhanced. *Digitizing* is the process by which the image is stored in memory. This is commonly done by scanning an image with a flatbed scanner or a digital camera and converting the image by computer into an array of digital intensity values called *pixels,* or picture elements (see p. 452). Once the image has been digitized, an image editing program such as Adobe Photoshop is used to adjust the image. An image may be enhanced through lightening, darkening, and color and contrast controls. An example of how the technology is applied to forensic document examination is shown in Figures 16–8 and 16–9.

OTHER DOCUMENT PROBLEMS

Indented writings are the partially visible depressions on a sheet of paper underneath the one on which the visible writing was done. Such depressions are due to the application of pressure on the writing instrument and would appear as a carbon copy of a sheet if carbon paper had been inserted between the pages.

Indented writings have proved to be valuable evidence. For example, the top sheet of a bookmaker's records may have been removed and destroyed, but it still may be possible to determine the writing by the impressions left on the pad. These impressions may contain incriminating evidence supporting the charge of illegal gambling activities. When paper is studied under oblique or side lighting, its indented impressions are often readable (see Figure 16–10). An inno-

vative approach to visualizing indented writings has been developed at the London College of Printing in close consultation with the Metropolitan Police Forensic Science Laboratory.[3] The method involves applying an electrostatic charge to the surface of a polymer film that has been placed in contact with a questioned document, as shown in Figure 16–11. Indented impressions on the document are revealed by applying a toner powder to the charged film. For many documents examined by this process, clearly readable images have been produced from impressions that could not be seen or were barely visible under normal illumination. An instrument that develops indented writings by electrostatic detection is commercially available and is routinely used by document examiners.

A study of the chemical composition of writing ink present on documents may verify whether known and questioned documents were prepared by the same pen. A nondestructive approach to comparing ink lines is accomplished with a visible microspectrophotometer (see pp.189–192).[4] A case example illustrating the application of this approach to ink analysis appears in Figure 7–10. Thin-layer chromatography is also suitable for ink comparisons. Most commercial inks, especially ballpoint inks, are actually mixtures of several organic dyes. These dyes can be separated on a properly developed thin-layer chromatographic plate. The separation pattern of the component dyes is distinctly different for inks with different dye compositions and thus provides many points of comparison between a known and a questioned ink.

Ink can be removed from paper with a hypodermic needle with a blunted point to punch out a small sample from a written line. About ten plugs or microdots of ink are sufficient for chromatographic analysis. Since 1968, the U.S. Treasury Department has been gathering a complete library of all commercial pen inks. These inks have been systematically cataloged according to dye patterns developed by thin-layer chromatography (TLC; see Figure 16–12). On several occa-

sions, this approach has been used to prove that a document has been fraudulently backdated. For example, in one instance, it was possible to establish that a document dated 1958 was backdated because a dye identified in the questioned ink had not been synthesized until 1959.

To further aid forensic chemists in ink-dating matters, several ink manufacturers, at the request of the U.S. Treasury Department, voluntarily tag their inks during the manufacturing process. The tagging program allows inks to be dated to the exact year of manufacture by changing the tags annually.

Another area of inquiry for the document examiner is the paper on which a document is written or printed. Paper is often made from cellulose fibers found in wood and fibers recovered from recycled paper products. The most common features associated with a paper examination are general appearance, color, weight, and watermarks. Other areas of examination include fiber identification and the characterization of additives, fillers, and pigments present in the paper product.

VOICE EXAMINATION

The Sound Spectrograph

In this era of telephone, radio, and tape-recorded communications, the human voice may often prove to be valuable evidence for associating an individual with a criminal act. The telephoned bomb threat, obscene phone call, or tape-recorded kidnap ransom message have all become frequent enough occurrences to warrant the interest of law enforcement officials in scientific techniques capable of transforming the voice into a form suitable for personal identification. To this end, a good deal of research and casework has been generated as a result of the development of the *sound spectrograph;* an instrument that converts speech into a visual graphic display.

The sound spectrograph was first developed at Bell Telephone Laboratories in 1941 during research devoted to studying speech signals as they related to communications services. During World War II, the instrument was used for intelligence purposes to identify the voices broadcast by German military communications. Following the war and during his employment with the company, a Bell System engineer, Lawrence Kersta, worked with this new technique and became convinced that voice spectrograms, or **voiceprints**, as he called them, could provide a valuable means of personal identification.

Kersta contended that each voice has its own unique quality and character, arising out of individual variations in the vocal mechanism (see Figure 16–13). The probability that any two individuals have the same size vocal cavities (throat, nasal, and two oral cavities formed by positioning the tongue) and coordinate their articulators (lips, teeth, tongue, soft palate, and jaw muscles) in a like manner is so small as to make the human voice a unique personal trait. According to Kersta, the voiceprint is simply a graphic display of the unique characteristics of the voice.

As a result of Kersta's claim, the sound spectrograph has attracted great interest among criminal investigators. Many law enforcement laboratories have purchased the instrument, and various courts have been asked to accept its results as evidence of an individual's participation in a crime. However, there are still conflicting opinions in the courts as to whether the voiceprint has gained a sufficient degree of "general acceptance" within the scientific community to satisfy its admissibility as scientific evidence. A detailed report on voiceprints by the National Academy of Science concluded that

> the degree of accuracy and the corresponding error rates of aural-visual voice identification vary widely from case to case, depending upon several conditions

> including the properties of the voices involved, the conditions under which the voice samples were made, the characteristics of the equipment used, the skill of the examiner making the judgments, and the examiner's knowledge about the case.[5]

The National Academy's concern that there is no adequate scientific basis for legal authorities to judge the reliability of voice spectrographic comparisons was addressed by a 1986 FBI study.[6] A survey of two thousand voice identification comparisons made by FBI examiners under actual forensic conditions found that meaningful decisions were made in only 34.8 percent of the requested comparisons, with observed error rates of 0.31 percent for false identifications and 0.53 percent for false eliminations. Because the error rates were determined from direct feedback from field investigators, which may not always be correct, these percentages represent minimum error rates. An error rate of 1 percent would seem to be realistic under typical case conditions.

The analog sound spectrograph converts the sound of a voice into a visual display called a *spectrogram* or *voiceprint*. The selected frequencies are converted into electrical energy and are recorded by a stylus on specially prepared chart paper. As the drum revolves, the variable filter moves to higher and higher frequencies while the stylus simultaneously records the intensity of each selected frequency range. Upon completion of the analysis, a print is produced that represents 2.5 seconds of tape time and contains a pattern of closely spaced lines showing all the audible frequencies in the tape segment.

Figure 16–14 demonstrates a typical voiceprint. The spectrum portrays three parameters of speech: time (horizontal axis), frequency (vertical axis), and the relative intensity or volume of the different frequencies. Intensity is proportional to the degree of darkness within each spectrographic region. Hence, in this manner, frequency patterns of identical or like-sounding words are

obtained from both the questioned and the known voice for visual comparison. When sufficient similarity exists between the two, a positive conclusion is justified that both voices may have emanated from the same person.

Voiceprints depicting the word *you* are shown in Figure 16–15. As an exercise in voiceprint comparison, the reader can attempt to match the questioned voiceprint on the upper left to the voice of one of the five suspects.

The recent introduction of the computerized sound spectrograph (see Figure 16–16) simplifies the work for today's examiners. This valuable tool allows multiple sound spectrograms to be displayed simultaneously and permits CD-quality playback of each recording. The reproducibility of the spectrograms by the computerized system is no different from the analog system, but offers many effective ways of analyzing recordings without compromising much sample preparation time. Common techniques used by examiners can be completed effortlessly with digital cuts and other editing features available with a computer. Simple acts such as adjusting of the recording's time alignment and range of frequency can aid in making a comparison. Furthermore, the examiner can remove much of the background noise that might lessen the recording's usefulness.

Examiners apply both aural and visual techniques when comparing two voice samples. A common way of performing aural analysis is to repeatedly re-record the selected segment. During the visual analysis, the spectrograms are placed side by side for rapid comparison. Only those that contain identical texts are compared and are digitally displayed for overall pattern recognition and identifiable features. Finally, the examiner can classify the recording into one of the following seven categories as recommended by the American Board of Recorded Evidence:

1. A positive identification with more than twenty matching speech sounds
2. A probable identification with more than fifteen matching sounds and no unexplained differences
3. A possible identification with more than ten matching sounds and no unexplained differences
4. An inconclusive decision mainly due to a poor recording
5. A possible elimination with ten or more sounds that do not match
6. A probable elimination with fifteen or more sounds that do not match
7. A positive elimination with twenty or more sounds that do not match

Notable applications of voiceprint technology have increased public awareness of this technique. For example, voiceprints played a part in Howard Hughes's refutation of Clifford Irving's purported autobiography of Hughes. A few days after McGraw-Hill and *Life* magazine announced their intent to publish Irving's work, Hughes Tool Company officials arranged for a telephone interview between the reclusive Howard Hughes in the Bahamas and a group of newspaper, radio, and TV reporters assembled in Los Angeles. At the request of one of the major TV networks, spectrographic comparisons of the voice from the Bahamas were made against a known sample of Hughes's voice recorded in 1947. The results proved beyond a doubt that the reporters had been conversing with Howard Hughes and not with an impostor. Irving was eventually found guilty of forging the "Hughes autobiography."

In another case, a perpetrator called the police to report that he had killed a woman and to reveal the location of the body. He gave his name as that of an acquaintance. During the course of the investigation, the man whose name was used was eliminated as the caller, and the perpetrator

was identified through voiceprint comparisons. Based on that identification, the impostor was found guilty and sentenced to prison.

Present use of forensic voiceprint technology is limited to a relatively small number of active examiners. Legal barriers to the admission of this evidence exist in many jurisdictions. This situation will likely remain unchanged until a consensus develops among the practitioners of this technology with regard to minimum education and experience for spectrographic examiners and a minimum set of uniform criteria for defining and evaluating voiceprint comparisons.

Chapter Summary

Any object with handwriting or print whose source or authenticity is in doubt may be referred to as a questioned document. Document examiners apply knowledge gathered through years of training and experience to recognize and compare the individual characteristics of questioned and known authentic writings. For this purpose, gathering documents of known authorship or origin is critical to the outcome of the examination. Many factors compose the total character of a person's writing. The unconscious handwriting of two different individuals can never be identical. Furthermore, the writing style of one individual may be altered beyond recognition by the influence of drugs or alcohol. The collection of an adequate number of known writings is critical for determining the outcome of a handwriting comparison. Known writing should contain some of the words and combinations of letters present in the questioned document.

The two requests most often made of the examiner in connection with the examination of typewriters and printing devices are to determine whether the make and model of the typewriter and printing devices used to prepare the questioned document can be identified and whether a particular suspect typewriter or printing device can be identified as having prepared the ques-

tioned document. The individual type character's style, shape, and size are compared to a complete reference collection of past and present typefaces. As is true for any mechanical device, use of a printing device results in wear and damage to the machine's moving parts. These changes occur both randomly and irregularly, thereby imparting individual characteristics to the printing device. The document examiner has to deal with problems involving business and personal computers, which often produce printed copies that have only subtle defects.

Document examiners must deal with evidence that has been changed in several ways, such as through alterations, erasures, and obliterations. Indented writings have proved to be valuable evidence. It may be possible to determine what was written by the impressions left on a paper pad. Applying an electrostatic charge to the surface of a polymer film that has been placed in contact with a questioned document visualizes indented writings. A study of the chemical composition of writing ink on documents may verify whether known and questioned documents were prepared by the same pen.

The human voice may prove to be valuable evidence for associating an individual with a criminal act. The probability that any two individuals have the same size vocal cavities (throat, nasal, and two oral cavities formed by positioning the tongue) and coordinate their articulators (lips, teeth, tongue, soft palate, and jaw muscles) in a like manner is so small as to make the human voice a unique personal trait. The sound spectrograph is an instrument that converts speech into a visual graphic display. Courts have been asked to accept its results as evidence of an individual's participation in a crime. However, there are still conflicting opinions in the courts as to whether the voiceprint has gained a sufficient degree of general acceptance within the scientific community to satisfy its admissibility as scientific evidence.

Review Questions

1. Any object that contains handwriting or typescript and whose source or authenticity is in doubt is referred to as a (n)_____.
2. Variations in mechanical, physical, and mental functions make it (likely, unlikely) that the writing of two different individuals can be distinguished.
3. In a problem involving the authorship of handwriting, all characteristics of both the _____ and _____ documents must be considered and compared.
4. True or False: A single handwriting characteristic can by itself be taken as a basis for a positive comparison. _____
5. True or False: Normally, known writings need not contain words and combinations of letters present in the questioned document. _____
6. As the age difference between genuine and unknown specimens becomes greater, the standard tends to become (more, less) representative of the unknown.
7. In the case of _____, the Supreme Court held handwriting to be nontestimonial evidence not protected by Fifth Amendment privileges.
8. When requested writing is being given by a suspect, care must be taken to minimize a (n) _____ writing effort.
9. Random wear and damage to a typewriter impart it with _____ characteristics.
10. Examination of a document under _____ or _____ lighting may reveal chemical erasures of words or numbers.

11. Some inks, when exposed to blue-green light, absorb _____ radiation and emit light.

12. Handwriting containing inks of different chemical compositions may be distinguished by photography with _____ film.

13. _____ writings are partially visible impressions appearing on a sheet of paper underneath the one on which the visible writing was done.

14. Many ink dyes can be separated by the technique of _____ chromatography.

15. The _____ was first developed at Bell Telephone Laboratories in 1941.

16. The sound spectrograph converts sound into a visual display called a (n) _____.

17. True or False: Voices analyzed by the sound spectrograph have been widely accepted as evidence in U.S. courts.

Further References

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Questioned Document

Any document about which some issue has been raised or that is the subject of an investigation.

Exemplar

An authentic sample used for comparison purposes, such as handwriting.

Natural Variations

Normal deviations found between repeated specimens of an individual's handwriting or any printing device.

Erasure

The removal of writing, typewriting, or printing from a document. It is normally accomplished by either chemical means or an abrasive instrument.

Infrared Luminescence

A property exhibited by some dyes that emit infrared light when exposed to blue-green light.

Obliteration

The blotting out or smearing over of writing or printing to make the original unreadable.

Charred Document

Any document that has become darkened and brittle through exposure to fire or excessive heat.

Indented Writings

Impressions left on papers positioned under a piece of paper that has been written on.

Voiceprint

A pictorial representation of the frequency, duration, and amplitude of human voice sounds.

Figure 16–1 Forged signatures of Howard Hughes and examples of Clifford Irving's writing. *Reprinted by permission of the American Society for Testing and Materials from the Journal of Forensic Sciences, copyright 1975*

Figure 16–2 A portion of a typewriting comparison points to the conclusion that the same machine typed both specimens. Besides the similarity in the design and size of type, note the light impression consistently made by the letter *M*. Also, the letter *E* slants to the right, almost touching *D* in the word *USED* in both specimens. *Courtesy New Jersey State Police*

Figure 16–3 (a) A twenty-dollar bill as it appears under room light. (b) The bill illuminated with ultraviolet light reveals ink writing. *Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com*

Figure 16–4 Part of a check stolen from a government agency as it appears to the naked eye is shown in (a). An infrared luminescence photograph was prepared of the amount figures at a magnification of 10× in (b). This clearly shows that the number 2 was added with a different ink. The accused pleaded guilty. *Courtesy Centre of Forensic Sciences, Toronto, Canada*

Figure 16–5 (a) This photograph, taken under normal illumination, shows the owner of an American Express check to be "Freda C. Brightly Jones." Actually, this signature was al-

tered. The check initially bore the signature "Fred C. Brightly Jr." (b) This photograph taken under infrared illumination, using infrared-sensitive film, clearly shows that the check was altered by adding *a* to *Fred* and *ones* to *Jr*. The ink used to commit these changes is distinguishable because it absorbs infrared light, whereas the original ink does not. *Courtesy New Jersey State Police*

Figure 16–6 (a) A photograph showing an area of a document that has been blacked out with a heavy layer of ink overwriting. (b) In this photograph, the covering ink has been penetrated by infrared photography to reveal the original writing. *Courtesy Centre of Forensic Sciences, Toronto, Canada*

Figure 16–7 Decipherment of charred papers seized in the raid of a suspected bookmaking establishment. The charred documents were photographed with reflected light. *Courtesy New Jersey State Police*

Figure 16–8 This composite demonstrates the various changes that can be applied to a digitized image in order to reveal information that has been obscured. Using a photo editor (Adobe Photoshop) the original was duplicated and pasted as a second layer. Colors were changed in selected areas of the image using the "screen" and "exclusion" options. "Replace color" allows the user to choose a specific color or range of colors and lighten, darken, or change the hue of the colors selected. "Level" and "curves" tools can adjust the lightest and darkest color ranges and optimize contrast, highlights, and shadow detail of the image for additional clarity. *Courtesy Lt. Robert J. Garrett, Middlesex County Prosecutor's Office, N.J.*

Figure 16–9 (a) Receipts have been used in investigations to establish a victim's where-

abouts, provide suspects with alibis, and substantiate a host of personal conduct. Unfortunately, many times due to wear, age, or poor printing at the register, the receipt may be unreadable. This can be corrected using photo-editing software. In this example, the original toll receipt was scanned at the highest color resolution, which allows more than 16 million colors to be reproduced. The image was then manipulated, revealing the printed details, by adjusting the lightest and darkest levels and the color content of the image. (b) Invoices may contain details about a transaction that are important to an investigation. The copy that ships with the merchandise may have that information blocked out. This information may be recovered using digital imaging. The left figure shows the original shipping ticket. The right figure shows the information revealed after replacing the color of the blocking pattern. *Courtesy Lt. Robert J. Garrett, Middlesex County Prosecutor's Office, N.J.*

Figure 16–10 A suspected forger was arrested. In his car, police found written lists of the victims he intended to defraud. Some of these writings are shown in (a). A writing pad found in his house had indentations on the top page of the pad shown in (b). These indentations corresponded to the writings found in the car, further linking the suspect to the writings. *Courtesy Centre of Forensic Sciences, Toronto, Canada*

Figure 16–11 An electrostatic detection apparatus (ESDA) works by applying an electrostatic charge to a document suspected of containing indented writings. The indentations are then visualized by the application of charge-sensitive toner. *Courtesy Foster and Freeman Limited, Worcestershire, U.K., www.fosterfreeman.co.uk*

Figure 16–12 Chart demonstrating different TLC patterns of blue ballpoint inks. *Courtesy Alcohol, Tobacco, Firearms and Explosives Laboratory, U.S. Department of Justice, Washing-*

ton, D.C.

Figure 16–13 Schematic of the vocal mechanism.

Figure 16–14 A voiceprint. *Courtesy New Jersey State Police*

Figure 16–15 A questioned voiceprint and voiceprints of five male speakers uttering the word *you*. Match the questioned voiceprint on the upper left to the voiceprint of one of the five suspects. (The upper left and lower right voiceprints are of the same person.)

Figure 16–16 A sound spectrograph. *Courtesy KayPENTAX., Lincoln Park, N.J.*

[1] 388 U.S. 263 (1967).

[2] 410 U.S. 19 (1973).

[3] D. M. Ellen, D. J. Foster, and D. J. Morantz, "The Use of Electrostatic Imaging in the Detection of Indented Impressions," *Forensic Science International* 15 (1980): 53.

[4] P. W. Pfefferli, "Application of Microspectrophotometry in Document Examination," *Forensic Science International* 23 (1983): 129.

[5] *On the Theory and Practice of Voice Identification*. Washington, D.C.: National Academy of Sciences, 1979.

[6] B. E. Koenig, "Spectrographic Voice Identification: A Forensic Survey," *Journal of the Acoustical Society of America* 79 (1986): 2088.