Linda R. Taylor,[1] *M.A.*

Intersecting Lines as a Means of Fraud Detection

REFERENCE: Taylor, L. R., **"Intersecting Lines as a Means of Fraud Detection,"** *Journal of Forensic Sciences*, JFSCA, Vol. 29, No. 1, Jan. 1984, pp. 92-98.

ABSTRACT: Document examiners are frequently asked to determine whether a questioned document is fraudulent or authentic. One approach to proving or disproving fraud is to determine the order of line sequence—which of two intersecting written lines was made last. In this paper, three current techniques available for systematically examining and removing layers of writing medium to determine line sequence are compared: the stereomicroscope method, the distilled water method, and the wax lift method.

KEYWORDS: questioned documents, intersecting lines, line sequence

The practice of altering or forging documents is almost as ancient as the art of writing itself [*1*]. Historical references reveal that during the Middle Ages forged documents were used as a fraudulent means of acquiring land titles [*2*]. During the twentieth century in the United States, fraud has become a matter of serious concern.

Forged checks alone are estimated at over $1 billion annually [*3*]. A single stroke of a writing instrument can mean a difference of many thousands of dollars. Fraudulent signatures or additions to wills, contracts, deeds, and other legal agreements create sometimes irreparable damage in terms of human suffering as well as severe financial loss.

Detecting fraud in questioned documents by the examination of intersecting lines is possible by various methods, three of which this paper will compare in statistical detail.

Design and Methods

The techniques described in this paper, while valid, are certainly not infallible. Factors such as the kind of writing instrument used; the quality and surface of the paper; the kind, quality, and color of medium used; and the density of strokes must be considered when determining line sequence. Because of these conditions, it is frequently very difficult and sometimes impossible to show which line was made last.

The three methods described in this paper have been tested for validity by using the Chi-square test, and their relative effectiveness has been compared under problem conditions of line density and color.

Four combinations of line density are possible: two strong lines crossing, two weak lines crossing, a strong line crossing a weak line, and a weak line crossing a strong line.

Variations in line color occur when dark strokes cross dark strokes, dark strokes cross light strokes, light strokes cross dark strokes, and light strokes cross light strokes.

The writing media selected to demonstrate these conditions were felt-tip pens, ball-point pens, fluid ink pens, graphite pencil, and carbon type.

Received for publication 19 March 1983; revised manuscript received 10 May 1983; accepted for publication 17 May 1983.

[1] Examiner of questioned documents, Arkansas State Crime Laboratory, Little Rock, AR.

The methods used to examine the intersections were the stereomicroscope, the distilled water method, and the wax lift method.

The stereomicroscope is an instrument of high magnification that has been very useful in determining line sequence, particularly when one is dealing with two crossed fluid ink strokes, by examining the way the ink flows or spreads along the lower or first stroke. This instrument has also been an effective tool for examining two crossed pencil line strokes, by viewing the direction of the fibers on the paper and the buildup of graphite on the track or groove made by the stroke. However, document examiners have had limited success with the stereomicroscope as a method of examination in determining line sequence under varying conditions of line color and density. For this reason, two alternative approaches were investigated and compared to the stereomiroscope, in an effort to present a more reliable method for establishing the order of intersection lines.

The distilled water method attempts to dissolve water-soluble media with distilled water at the point of intersection. A syringe needle is used to apply one droplet of water to the intersection of two lines for a period of 2 min. The water droplet is absorbed into a piece of filter paper as the sharp edge of the paper is brushed gently across the point of intersection, in an attempt to remove the uppermost line. A stereomicroscope is used to observe the point of intersection before and after the water is applied to the writing surface.

The distilled water method has three major disadvantages:

(1) it can only be applied to water-soluble media and combinations of water-soluble and non-water-soluble media,

(2) only the original intersection can be viewed for establishing the order of line sequence, and

(3) the original intersection is altered after the water has been applied.

The other method compared to the stereomicroscope was the wax lift method. This method requires a solvent that can effectively dissolve nonwater-soluble media. Triton X-100 [4] was chosen as a nonionic detergent to be used for penetrating these media and dispersing the materials throughout the solution. The solvent is applied to a wax paper to slow down the reaction of the media. The application of the solvent to the wax paper involves brushing the solvent directly onto the back or (unwaxed) side of a sheet of polyfreeze paper. After the solvent is applied to the paper, the treated paper is placed on two intersecting lines with the wax side up. A blunt instrument is used to apply pressure to the point of intersection. After the treated paper has penetrated the intersection for a period ranging from 30 s to 2 min (depending on the type of medium used and the density of the stroke), a sheet of untreated polyfreeze paper is placed wax side down on the intersection in an attempt to lift the uppermost line. Again, a blunt instrument is used to apply varying amounts of pressure to the point of intersection, depending once again on the type of medium and density of the stroke. A stereomicroscope is used to observe the point of intersection before and after the wax lift is applied to the writing surface.

The wax lift method has two advantages over the stereomicroscope and the distilled water methods:

(1) the examiner can view the original intersection and the reverse image supplied by the wax lift and

(2) the wax lift method can be applied to both water-soluble and nonwater-soluble media.

One disadvantage is that the original intersection is altered after the wax lift is applied.

Analysis of Data

The experimental data revealed that in 164 test combinations of intersecting lines of various color, the wax lift method was significantly more effective overall than the other two methods.

This was true specifically when two dark lines crossed, when one dark line crossed a light line, and when two light lines crossed. The wax lift did not produce more effective results when a light line crossed a dark line; under this condition the wax lift and the stereomicroscope produced equal results. Figure 1 graphically illustrates these conclusions.

Under 137 test combinations of line density, the wax lift technique was again significantly more effective than the stereomicroscope. This was true specifically when two strong lines crossed, when two weak lines crossed, and when a strong line crossed a weak line. There was no significant difference between the wax lift and the stereomicroscope when a weak line crossed a strong line. Likewise, there was no significant difference between the wax lift and the distilled water techniques when a strong line crossed a weak line. Figure 2 illustrates these results.

An overall survey of the 301 tests conducted indicated that the most effective method used in the determination of line sequence was the wax lift method in combination with the stereomicroscope.

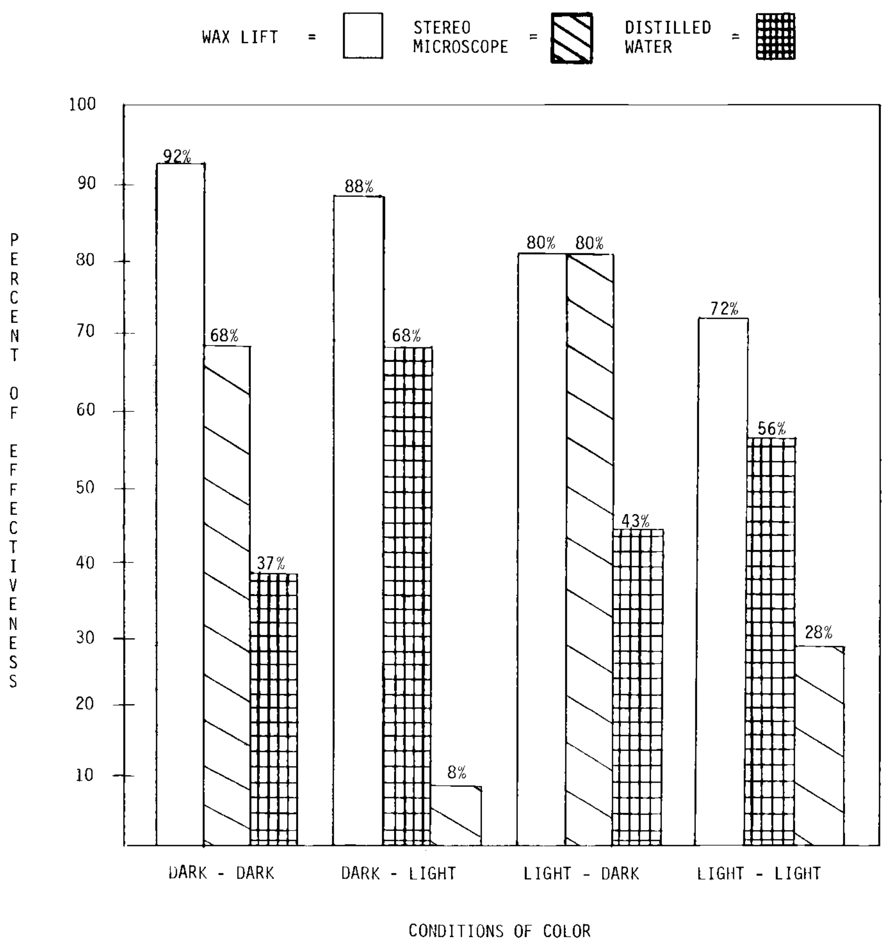

FIG. 1—*Comparative effectiveness of the wax lift, stereomicroscope, and distilled water techniques under varying color conditions.*

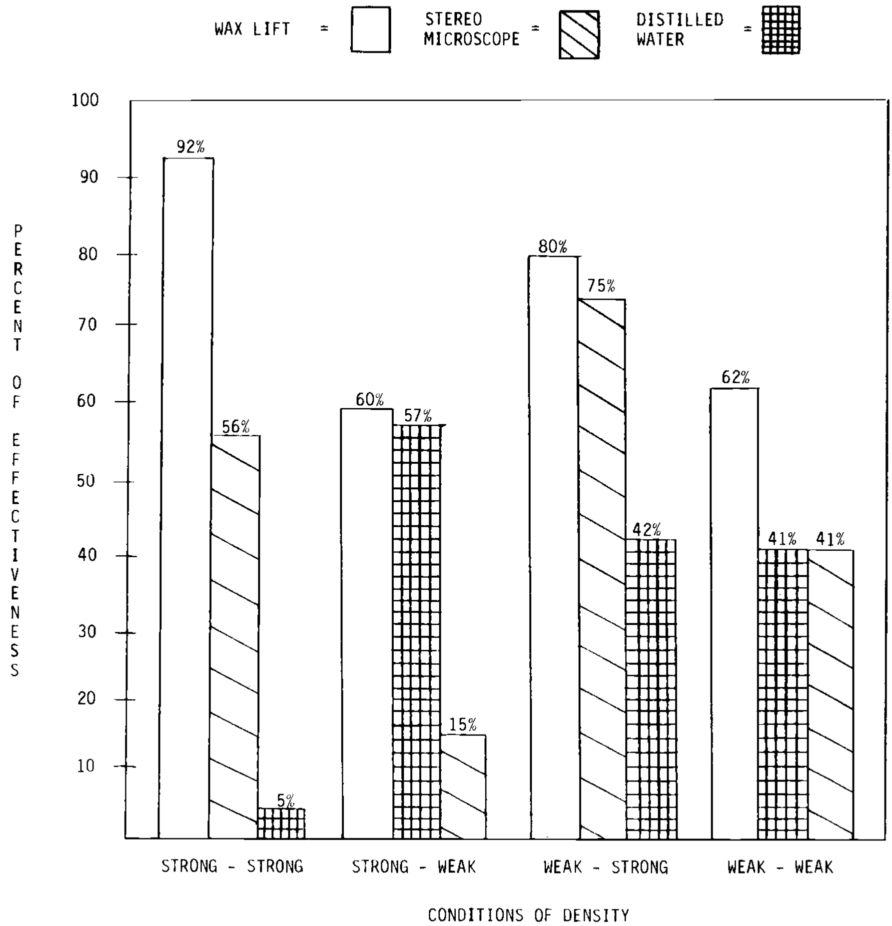

FIG. 2—*Comparative effectiveness of the wax lift, stereomicroscope, and distilled water techniques under varying conditions of density.*

Conclusion and Observations

After applying the wax lift technique and the distilled water technique to intersecting lines of varying density and color, several incidental observations were made:

1. Changes in the chemical composition of the writing medium varied when using the wax lift, depending on the length of the time the solvent was allowed to penetrate the writing line, the density of the stroke, and the type of medium used. For example, the tests indicated that ball-point pen ink appeared to be the best reactor to the solvent when the wax lift was applied. Carbon type and graphite were the only media that could be lifted effectively by the wax lift without prior treatment by the solvent (see Figs. 3 and 4).
2. The quality of the wax lift also depended on the amount of pressure applied when the writing medium was lifted at the point of intersection.
3. By using the distilled water technique, carbon and graphite could be floated off the writing line when a water-soluble medium was underneath the carbon or graphite line (see Fig. 5).

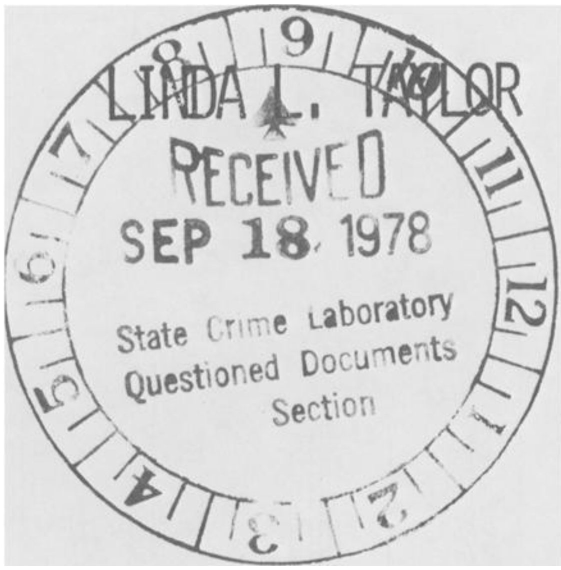

FIG. 3—*Intersection of receiving stamp and typewritten name.*

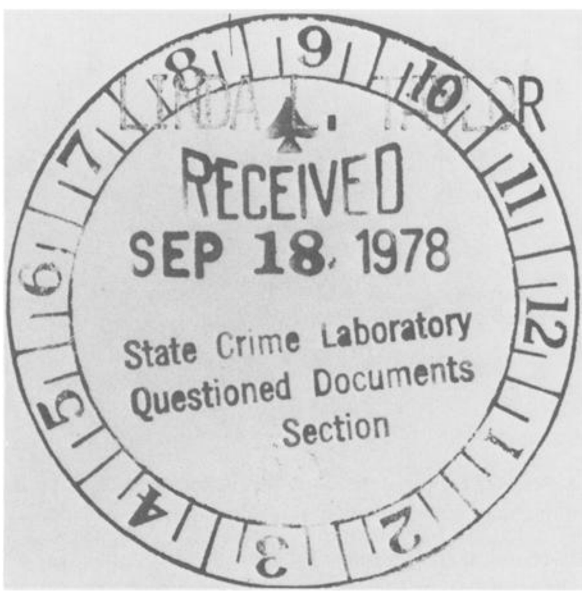

FIG. 4—*Intersection after wax lift has been applied.*

4. Water-soluble media could not be dissolved in some instances by using the distilled water technique when they were underneath an oil-based ink, especially one of strong density (see Fig. 6).

The wax lift and distilled water techniques have been effective in determining the sequence of strokes under problem conditions of line density and color. However, practical application

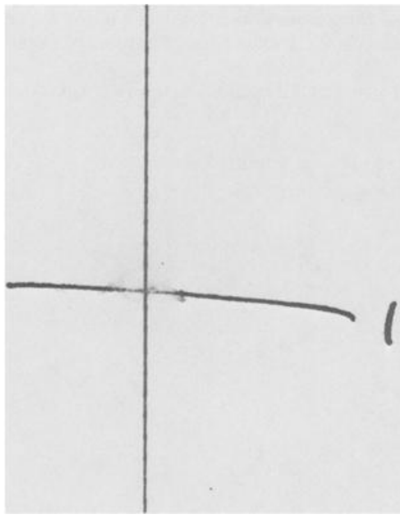

FIG. 5—*The vertical typewritten line is floated from the water-soluble black felt tip line at the point of intersection.*

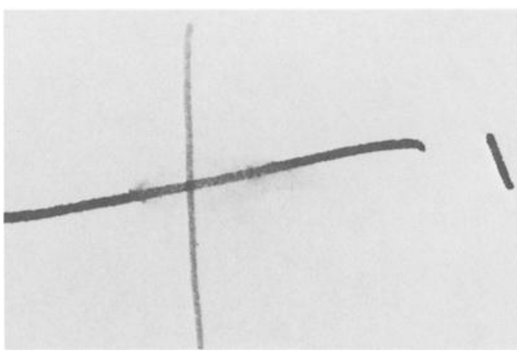

FIG. 6—*The water-soluble black felt tip ink is preserved under the vertical blue ball-point ink.*

by the user is an absolute necessity to gain any degree of proficiency in using and selecting the appropriate method for a particular line sequence determination. Examiners must avail themselves of different media, papers, and reagents to properly interpret any test results.

Acknowledgments

Grateful acknowledgment is extended to Mr. Howard "Bear" Chandler, Chief Examiner of Questioned Documents and Mr. Harold Page, Chief Forensic Photographer of the Arkansas State Crime Laboratory, for their assistance in this research.

References

[1] Harrison, W. R., *Suspect Documents: Their Scientific Examination*. Fredrick A. Praeger, Inc., New York, 1958, p. 1.

[2] Osborne, A. S., *Questioned Documents*, Boyd Printing Co., New York, 1929, p. vii.
[3] *A Handbook on White Collar Crime*, United States Chamber of Commerce, Washington, DC, 1974, p. 6.
[4] McCutcheon, J. W., *Detergents and Emulsifiers Annual 1970*, Allured Publishing Corp., Ridgewood, NJ, 1970, p. 243.

Address request for reprints or additional information to
Linda L. Taylor
Arkansas State Crime Laboratory
P.O. Box 5274
Little Rock, AR 72212