

# An evaluation of line quality in photocopied signatures

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Qualified forensic document examiners from Canada, USA, Great Britain and Australia participated in this study. They were sent one photocopied signature, together with a set of original known standards to evaluate the line quality of the photocopied signature and compare these characteristics with the standards. They were asked to assess the photocopies for the presence of tremor, hesitation, pen lifts, patching, blunt initial or terminal strokes, and abrupt changes in direction. The authors compared the assessments with the corresponding original signatures. It was possible to determine which line quality characteristics were the most difficult to detect, which indicia of simulation were concealed and what anomalies were introduced by the photocopying process. Results indicated that line quality characteristics can be identified in average quality photocopies. Furthermore, accurate judgements can be made regarding similarities and differences in line quality when comparing a photocopied signature with original known standards. In a few instances, ink line morphology was problematic when striation patterns and ink gooping were misinterpreted as pen lifts, hesitation and patching on the photocopies.

Des experts en document qualifiés du Canada, des Etats-Unis, de Grande-Bretagne et d'Australie ont participé à cette étude. Chacun a reçu une signature photocopiee, ainsi qu'un jeu de standards originaux connus, pour évaluer la qualité du trait de la signature photocopiee et comparer celle-ci aux standards. Les participants devaient évaluer les photocopies pour la présence de tremblements, d'hésitations, de levers de plume, de reprises, de traits initiaux ou terminaux émoussés et de changements de direction abruptes. Les auteurs ont comparé les évaluations avec les signatures originales correspondantes. Il a ainsi été possible de déterminer quelles caractéristiques du trait étaient les plus difficiles à détecter, quels indices de simulation étaient cachés et quelles anomalies étaient introduites par le processus du photocopiage. Les résultats ont montré que les caractéristiques de qualité du trait peuvent être identifiées sur des photocopies de qualité moyenne. De plus, des jugements exacts peuvent être faits en ce qui concerne les similarités et les différences en qualité de trait lorsque une signature photocopiee est comparée avec le standard original connu. Dans peu de cas, la morphologie du trait d'encre était problématique sur les photocopies lorsque des motifs striés ou de bavure d'encre étaient mal interprétés comme des levers de plume, de l'hésitation ou une reprise.

Qualifizierte kanadische, amerikanische, britische und australische Schriftprüfer haben an dieser Studie teilgenommen. Ihnen ist die Photokopie einer Unterschrift übersandt worden sowie mehrere Originalunterschriften als Standards. Es sollte die Strichqualität der photokopierten Unterschrift ausgewertet und deren Merkmale mit den Standards verglichen werden. Dabei sollte an der photokopierten Unterschrift das Auftreten von Tremor, Absetzung, Neu-Ansetzungen, Anflickung, stumpfem Anstrich, Schlußzügen und abrupten Richtungswechseln festgestellt werden. Die Autoren haben die Feststellungen mit den entsprechenden Originalunterschriften verglichen. Es konnte bestimmt werden, welche Strichmerkmale am schwierigsten und welche nicht mehr zu erkennen waren und welche Anomalien durch das Photokopieren verursacht worden sind. Die Ergebnisse zeigen, daß in Photokopien durchschnittlicher Qualität die Strichmerkmale bestimmt werden können. Unter Berücksichtigung der Übereinstimmungen und Unterschiede können richtige Entscheidungen getroffen werden, wenn die photokopierte Unterschrift mit Originalunterschriften verglichen wird. Nur in wenigen Fällen ergaben sich aus der Struktur der Schreibmittelablagerung Probleme, wenn bei den Photokopien Bördelungsbilder und Scheibmittelverschmierungen fälschlicherweise als Neu-Ansetzungen, Absetzung und Anflickung interpretiert wurden.

Participaron en este estudio cualificados peritos de examen so documentos de EE.UU., Canadá, Gran Bretaña y Australia. Se les envió fotocopias de unas firmas junto con un conjunto de patrones conocidos originales para evaluar la calidad de la firma fotocopiada y compararla con los patrones. Se les pidió que valoraran en las fotocopias la presencia de temblor, vacilación, saltos de pluma, borrones, rasgos iniciales y finales y cambios abruptos de dirección. Los autores compararon las valoraciones con las correspondientes firmas originales. Fue posible determinar qué características de la calidad de la firma eran las más difíciles de detectar, qué indicios de simulación quedaban ocultos y qué anomalías eran introducidas por el proceso de fotocopiado. Los resultados indicaron que las características de calidad de la línea podían ser identificadas en fotocopia de calidad media. Además, se podían hacer juicios bastante precisos en relación a similitudes y diferencias en la calidad de la firma cuando se comparaba una firma fotocopiada con patrones originales conocidos. En algunos casos, la morfología de la tinta en la línea fue problemática, interpretándose una trama de estrías y pegotes de tinta como saltos de pluma, vacilaciones y manchas en las fotocopias.

*Key Words:* Forensic science; Questioned document examination; Photocopy; Signatures; Line quality; Ink.

## **Introduction**

The controversy regarding the propriety of conducting a forensic examination of photocopies is as old as the office copier. Document examiners are often faced with situations where the originals are not available or no longer exist. Some examiners do not express positive conclusions in a photocopied signature examination for fear that the copying process may have concealed or introduced evidence of simulation. A qualified opinion, such as 'probably wrote' or 'probably did not write' is usually expressed with an accompanying remark that a more positive conclusion may be possible if the original is received for examination. Sometimes a positive conclusion is given with the caveat that 'this result can be confirmed by examination of the original'. Other document examiners will only render a positive opinion when there are multiple forged photocopied signatures.

One author (name unknown) comments that photocopies seldom disclose with sufficient clarity such details as pen lifts, retouching, and shading which might indicate that a writing is forged rather than genuine [1]. A year earlier, Swett lamented the fact that many document examiners believe an examination cannot be done if the original is unavailable. He felt that nothing could be further from the truth and cited cases where the simulation or tracing was so poor that a definite conclusion of forgery could be accurately rendered [2]. Beck noted that signs of forgery are specific, while signs of genuineness are not. He theorized that the difficulty lies with photocopied signatures that appear to be genuine. The risk of error is greater when evaluating signatures lacking the indicia of non-genuineness [3]. Ellen stated that document examiners should not reject photocopies without attempting to ascertain what features they contain. When sufficient detail is visible photocopied handwriting can be identified to the known writer [4]. By 1989 Morton felt that photocopy reproductions had improved to the point where it was possible to express positive conclusions. This finding was based on her investigation of reproductions generated on seven plain paper office copiers, using a combination of six writing instruments and four paper stocks [5].

Consideration of line quality characteristics is important in any determination of a signature's genuineness. Document examiners prefer to analyse originals because photocopies are thought to conceal the finer details of line quality. Forgers may be able to reproduce letter designs but are usually unable to do so with the degree of writing fluency and skill reflected in the natural genuine signature.

The current study was designed to determine to what extent the photocopying process inhibits the appraisal of line quality. Which specific line quality characteristics are detectable in a photocopy and which are not? Will the features introduced or concealed by the photocopying process impact on the assessment of overall line quality?

First generation photocopies of seventy-two different genuine and non-genuine signatures were evaluated by document examiners from several countries. A comparison was made of their line quality assessments with the line quality characteristics in the corresponding original signatures. Almost 96% of the line quality features in the originals were identified on the photocopies. The same percentage was recorded in judgements of similarities and differences in line quality between the known original samples and the questioned photocopied signature. Tremor, blunt initial and terminal strokes and abrupt changes in direction were more readily detected than pen lifts, hesitation and patching/retouching.

## **Materials and Methods**

'Weekly Activity Registers' are completed and signed by staff at the Centre of Forensic Sciences in Toronto and are kept on file for a period of five years. These forms were the source of signatures for this research project. Selection of specific registers for inclusion in the study was based on the employee's ability to participate in the production of non-genuine signatures.

Registers for the week ending April 26, 1991 were chosen as the questioned documents. Twenty samples from the remaining 1991 forms were selected for comparison purposes, and divided into two groups. Ten original contemporary samples were provided for each test signature (one genuine and one non-genuine) to be evaluated. These samples would be considered ideal in an actual case.

The questioned signatures (April 26/91) were randomly mixed and then paired. Writers in each set copied each other's signature on blank Weekly Activity Registers. Only one person attempted to trace the signature, all others attempted freehand simulations after practice. The following scenario illustrates the conditions under which the non-genuine signatures were prepared.

Wendy Kinsman was paired with Shirley Stefak. Wendy was directed to forge the genuine Shirley Stefak signature, using the example appearing on the April 26/91 Activity Register as a model. No limit was set on the amount of practice time nor was she directed by which method to use, tracing or freehand simulation. When Wendy indicated she was ready to attempt the forgery, she was given five blank register forms. After producing an imitation of the signature on each of the forms, she was asked to select her preferred forgery. This signature became the questioned test sample; the remaining four attempts were discarded.

Next, Shirley Stefak was given the genuine Wendy Kinsman Activity Register. She was requested to forge Wendy's signature using this model, and according to the procedures outlined earlier. Shirley was then asked to complete the remainder of the form upon which Wendy Kinsman had produced the forgery. In this way, the Weekly

Activity Register bearing the non-genuine signature resembles the other genuine forms. Similarly, the details on the Activity Register bearing the Shirley Stefak forgery of Wendy's signature were completed by Wendy.

Each session was monitored and participants were encouraged to *imitate* the model, rather than simply execute the signature in their own writing style. Participants chose their method of forgery without guidance from the monitor.

This study was designed to ensure that average quality first generation reproductions were the subject of evaluation. To this end, forgers were asked to use a black ball-point, rollerball or fine fibre-tip pen that would yield a good quality photocopy. Some of the ballpoint pens exhibited minor striations and gooping but none seriously malfunctioned. While the majority of writers produced the forgeries in black ink, a few chose blue ink pens. The genuine sample signatures had been executed using a variety of pens, some of which produced signatures bearing striations and ink gooping.

The genuine and forged Weekly Activity Registers were photocopied. All copies were produced at 100%, on one photocopier and at the same time. A worksheet was then prepared by reproducing the photocopied questioned signature at 200% enlargement. No investigation was made of variable copy quality or the problems of assessing a multi-generation copy.

Letters of request to participate in the research project were sent to forensic document examiners with membership in the Canadian Society of Forensic Science and the American Society of Questioned Document Examiners, diplomates of the American Board of Forensic Document Examiners Inc. and to selected document examiners in Australia and Great Britain.

Packages were prepared containing a letter of instruction and an evaluation form (Appendix A), a worksheet, one of the photocopied questioned signatures, and ten original sample signatures. Each of the one hundred respondents who agreed to participate was sent a package.

The forensic document examiners were required to: assess the line quality of the photocopied questioned signature; assess the line quality of the original sample signatures; compare the line quality of the questioned and sample signatures; make notes on the worksheet regarding the line quality characteristics of tremor, blunt initial and terminal strokes, patching/retouching, inconspicuous pen lifts, hesitation, and abrupt changes in direction.

Seventy-two completed evaluations were returned. The authors examined each corresponding original questioned signature with a stereoscopic microscope, using a 200% enlargement of the original signature as a worksheet to note the location of the line quality characteristics mentioned above. This data was then compared with the responding

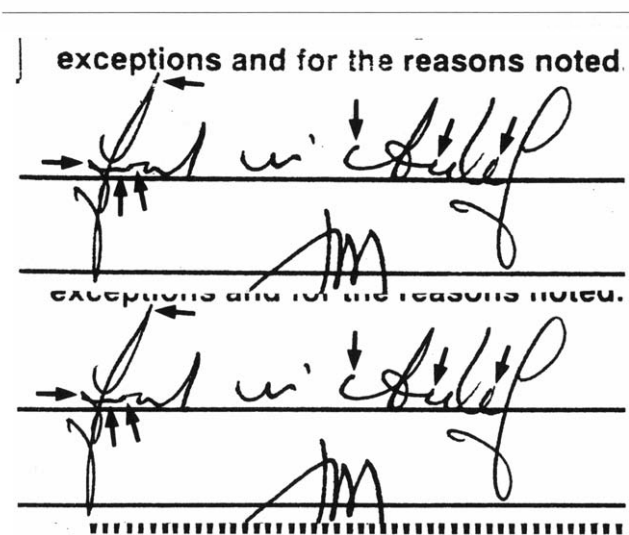


FIGURE 1 (a) photocopy of signature (b) original signature.

forensic document examiner's evaluations of the questioned photocopied signatures. Some features could be characterized in more than one way. What was identified as a hesitation on the photocopy proved to be a pen lift, or, an abrupt directional change noted on the photocopy was accompanied by a pen lift. Both of these assessments were regarded as accurate because they described the fundamental movement.

### Results and discussion

Results are provided for seventy-two test signatures. The overall line quality characteristics in 69 of 72 tests (95.8%) were accurately assessed in the photocopies, representing 33 of 35 (94.3%) genuine and 36 of 37 (97.3%) non-genuine signatures. In this same 69 of 72 responses, similarities and differences in line quality characteristics were accurately distinguished between the photocopied questioned signature and the known samples.

An example of the fine detail that can be seen in an evaluation of a photocopy is illustrated in Figure 1 (Frank McAuley). The upper signature shows the line quality characteristics identified in the photocopy of a non-genuine signature; the lower signature is the original with the corresponding features indicated.

Although not every single feature of line quality was properly detected and/or interpreted this did not lead to inaccuracies in the overall assessment. Particular line quality characteristics proved to be more difficult to see than others. Table 1 summarizes our data by illustrating the number of tests where a feature was either not detected or misjudged.

Where misinterpretations occurred, they were more likely to be related to the features of pen lifts, hesitation and patching. Tremor, blunt initial and terminal strokes and abrupt changes in direction were more readily detected and less likely to be misjudged. Noting each and every

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FIGURE 2 An example of prominent ink striae throughout the writing which was accurately interpreted in the photocopy.

occurrence of a pen lift in the copied signature proved to be more problematic than detecting all other features of line quality combined.

Ink line morphology defects were not usually problematic. Figure 2 (W Kinsman) is an example of prominent ink striae throughout the writing which was accurately interpreted in the photocopy. In Figure 3 (H. Wilson) the initial 'H' appears very ragged, yet the signature in its entirety shows fluency and tapering of strokes. While this feathering could have been improperly interpreted as tremor, a consideration of the writing as a whole resulted in the correct assessment.

Ink line morphology led to misinterpretations of line quality characteristics in 16 of the 72 tests. Striae patterns were present in 33 of the original questioned genuine and non-genuine signature samples. They were the source of a feature misjudgment at a specific location in 13 of these tests. The presence of ink striae had no impact on the evaluation of overall line quality in 31 of the 33 signatures. Ink gooping was a problem in two tests; pen failure in one.

Figure 4 (A. Tessarolo) illustrates one instance of a striae misinterpreted as a pen lift and another interpreted as a hesitation.

TABLE 1 Number of tests where a feature was misjudged.

Line Quality Feature	Occurrences – Number of Tests
pen lifts	25
hesitations	8
patching	7
tremor	5
blunt initial and terminal strokes	2
abrupt changes in direction	1

Branch duties during the week indicate exceptions and for the reasons noted



FIGURE 3 An example of feathering.

The effect of ink gooping on line quality is illustrated in Figure 5 (Lorne Blunt–non-genuine signature). There were many line quality problems which were accurately identified by the responding document examiner. However, ink gooping was misinterpreted as two instances of patching and one of hesitation.

In addition to ink line morphology defects, on occasion pen strokes which intersected and ran parallel to the printed signature line were obscured. Consequently it was not always possible to determine whether or not a pen lift or hesitation occurred at this location (Figure 6–Joan Simpson).

Assessment of line quality in three of the 72 tests was inconsistent with the line quality of the originals. In two of the three inaccurate evaluations of overall line quality, ink striae was a factor. In one genuine signature the improper result was due to misinterpretation of the striae patterns as inconspicuous pen lifts and patching. Likewise, in another signature ink striae were misinterpreted as patching and tremor. The cause of the third misinterpretation could not be determined.

### Conclusions

In today's business community the acceptance of non-original documents is standard practice. As a consequence, reproductions are frequently submitted to forensic laboratories for analysis. Photocopy reproductions are improving every year; with new technology it is likely this trend will continue. This study provides empirical support for document examiners' ability to make accurate observations regarding features on non-original signatures.

In a forensic investigation of photocopies the document examiner must decide whether or not the detail is sufficiently clear to permit an adequate examination. Clearly, a fourth generation copy of a signature written in light blue ink will pose a greater problem than a first generation copy of a signature in black ink. The results show that document

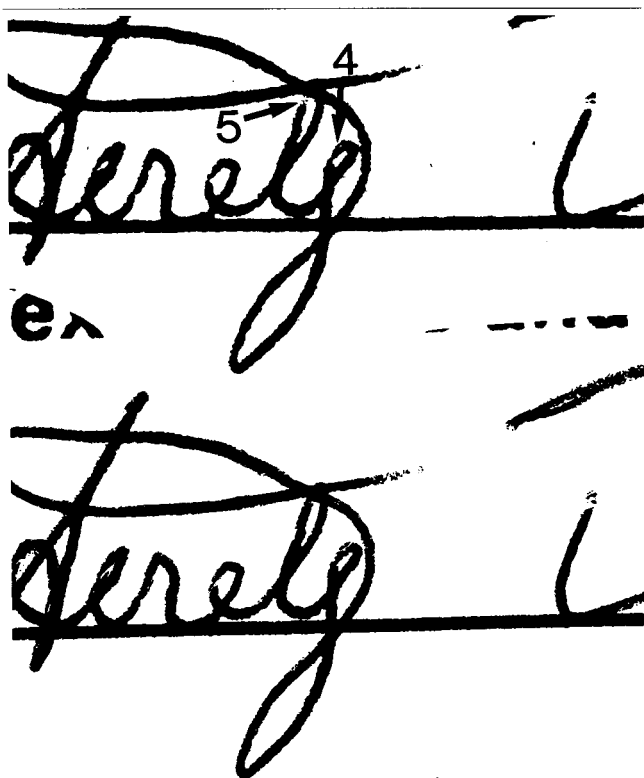


FIGURE 4 One instance of a striae misinterpreted as a pen lift and another interpreted as a hesitation.

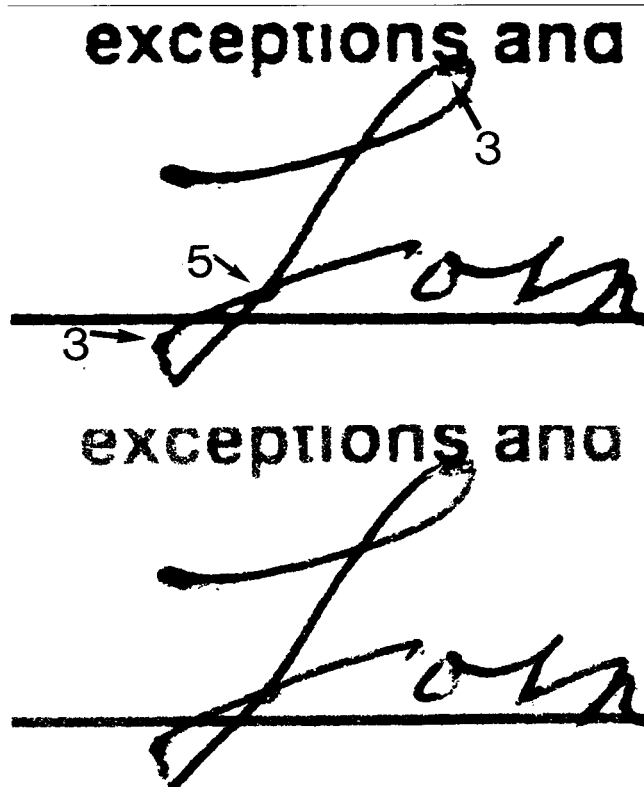


FIGURE 5 The effect of ink gooping on line quality.

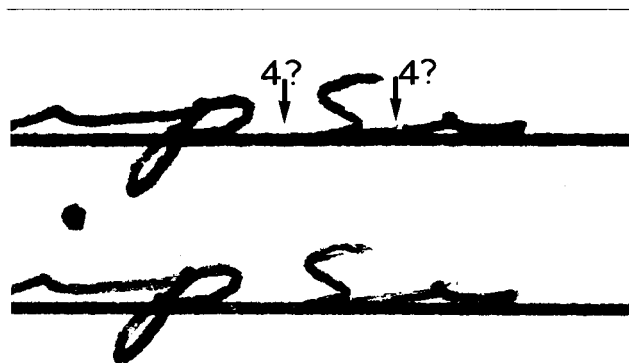


FIGURE 6 Example of pen lift or hesitation?

examiners missed very few elements of line quality when presented with average quality first generation photocopies.

The evaluation of overall line quality is not seriously hampered by the analysis of non-original signatures. All line quality characteristics were found to be detectable in a photocopy, although some were more readily observed than others. Failure to note each and every occurrence of a line quality characteristic did not impact on the overall evaluation as evidenced by an accuracy rate of 95.8%.

Most document examiners properly evaluated ink line morphology defects. In two of the three instances where the assessment of line quality was inaccurate, the questioned signature was laden with ink striae.

The ability to accurately assess line quality in photocopies will come through training and experience. Training should include components on the analysis of non-original handwriting. The programme should also incorporate indicators of ink striae and gooping in photocopy reproductions. This training could take the form of blind tests, much the same as was done for this project.

A final cautionary note is necessary. Determining the genuineness of a copied signature is only one element of the document examiner's job. The possibility that the reproduced signature is the product of a cut and paste manipulation or was created by a scan and copy technique must also be considered. The authors strongly advocate a complete assessment of any non-original document.

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**APPENDIX A**  
**EVALUATING LINE QUALITY IN PHOTOCOPIED SIGNATURES**

Thank you for agreeing to participate in this study. Each participant will receive either a genuine or spurious signature for analysis. The experimental design has been constructed **specifically** to test the effects of photocopy reproduction on *line quality* characteristics. Therefore, your analysis will not encompass individual features such as letter design, proportions, slope, alignment, spacing, etc.

Each test will be anonymous. **Do not** record your name on either the Evaluation Form or the Work Sheet. The purpose of this study is not to compare one examiner's skills against another's, but to determine which *line quality* features can, or cannot, be accurately evaluated in photocopies.

To ensure consistency in this project we will be using the definition of *line quality* stated in Ordway Hilton's book *Scientific Examination of Questioned Documents*, Revised Edition, 1982.

*Line Quality* – a term characterizing the visible record in the written stroke of the basic movements and manner of holding the writing instrument. It is derived from a combination of factors including writing skill, speed, rhythm, freedom of movement, shading and pen position. (page 19)

Please keep this definition in mind as you complete the exercise. It is important that you restrict your analysis to this writing feature **only**.

Your package should include the following:

- a) one photocopied questioned signature, labelled **Q**
- b) ten original specimen signatures, labelled **K**
- c) one Evaluation Form.
- d) one Work Sheet.

If you do not have all of the noted enclosures please contact Greg Dawson immediately.

*Instructions*

1. On the **Work Sheet** indicate the locations of any of the features listed below, which you feel are present in the questioned signature. Use hand-drawn arrows and the corresponding feature number.

1. tremor
2. blunt initial or terminal stroke
3. patching

4. inconspicuous pen lift
5. hesitation
6. abrupt change in direction

2. Compare the line quality characteristics of the **Q** and **K** signatures. In the space provided on the **Evaluation Form** record your observations.

3. Return all materials to Greg Dawson, Document Section, Centre of Forensic Science, 25 Grosvenor St, Toronto, ON M74 2GA.

EVALUATION FORM

For: Research Project - Evaluating Line Quality in Photocopied Signatures

Signature Test #: \_\_\_\_\_

Signature in Question: \_\_\_\_\_

Comparison of *line quality* on **Q** and **K** signatures

A. Overall comment on **Q** *line quality* (i.e. shows: fluency, rhythm, rapid or slow execution, heavy pen pressure, etc.)

\_\_\_\_\_  
 \_\_\_\_\_

B. Overall comment on **K** *line quality*

\_\_\_\_\_  
 \_\_\_\_\_

C. Are the line quality characteristics the same in the **Q** and **K** signatures?

yes \_\_\_\_\_ no \_\_\_\_\_

D. Based on line quality only is the **Q** signature:

- consistent with being executed by the writer of the **K** signatures

inconsistent with being executed by the writer of the **K** signatures \_\_\_\_\_