A Study on the Levels of Difficulty in the Simulation of Individual Characteristics in a Signature

Gek-Kwee Lee, Bei-Sing Yap, Chiew-Yung Yang, Lee-Tiang Lee, Sock-Kim Tan, and Koon-Puay Tan

Document Examination Laboratory, Centre for Forensic Science, Health Sciences Authority, 11 Outram Road,, Singapore 169078

This study looks at the levels of difficulty in simulating a signature with respect to 12 selected individual characteristics in a model signature. The objective was to find out which of these features in the signature were relatively easy or difficult to simulate and to compare the results with those expected based on the team's knowledge and experience in forensic handwriting and signature examination. Sixty-two volunteers took part in the study. The results of the analysis show that the experimental data is generally in agreement with the expected relative levels of difficulty of the characteristics studied. This study provides good evidence that the principles and knowledge applied in forensic handwriting and signature examination are sound and reliable and that characteristics in a person's signature are individualized.

Introduction

Simulated Signatures

When a document containing a disputed signature is submitted for examination, the request is usually to determine whether the signature is genuine, a simulated forgery, or written by a particular writer based on a comparison with his/her known specimens. In many cases, the examination reveals that a questioned signature was not written by the purported writer. To avoid suspicion, a good simulated forgery needs to fulfill 2 conditions. First, it has to be accurate in shape, formation, and proportion. This is typically achieved by copying the genuine signature slowly and with care. However, by doing this, there is an inevitable loss of fluency. Retouching, tremors, hesitations, consistent pen pressure, blunt beginning and terminal strokes, and unnatural pen lifts are just some of the common indications of forgery (Ellen 1997, Hilton 1982). Second, the simulated signature must be smoothly and fluently written. To achieve this, the signature has to be written quickly and as naturally as possible, but this often results in inaccuracies. For most people, it is impossible to manage both accuracy and fluency at the same time when simulating the signature of another person.

Some of the Existing Work on Signature Forgery and Disguise

Numerous papers about signature forgery and disguise have been published. Some have concentrated efforts on the different methods of disguise of signatures (Mohammed 1993, Keckler 1997; Wendt 2000) or whether people always disguise their signatures the same way (Vargas 2003). On the topic of simulated signatures, Muehlberger (1990) considered the characteristics of simulated forgeries and the conditions that enable the comparison of simulations with handwriting of suspected forgers. M. Singh and S. Singh (1999), and Smith (1995) reported their respective experiences in case reviews on simulated signatures.

Actual surveys or experiments on simulation of signatures seem to be limited. Herkt (1986) surveyed 144 people in an attempt to gather information on the likely methods of producing disguised and forged signatures, discussing in detail the methods of disguise and traced forgeries, and touched on simulated forgeries. Vardhan, et al. (1991) conducted research on writing movement being a key factor in individualizing and identifying handwriting, which can be important in determining forgery. Leung, et al. designed experiments and reported their findings on forgery by simulation (Leung, Cheng, Fung, and Poon

1993) and tracing (Leung, Fung, Cheng, and Poon 1993), but their main focus was on handwriting and symbols, not on signatures.

Objectives of this Research

To approach this topic from a different angle, the laboratory conducted a study on the levels of difficulty in simulating a signature with respect to selected individual characteristics present in that particular signature. The objective of this research was to find out which of these features were relatively easy or difficult to simulate and to compare the results with those expected based on the team's knowledge and experience in forensic handwriting and signature examinations. Depending on the results, this investigation could be extended to include a larger pool of participants. The information obtained could prove to be potentially useful in daily casework.

Methods and Materials

Selection of a Model Signature

A suitable signature from among those of the laboratory staff was selected. This signature was used as the model for the participants in this survey to attempt to simulate. Particular points were considered in the selection of the signature:

1. The formation and sequence of strokes of the signature should not be too complicated, as the participants may feel intimidated by its complexity.
2. The signature should not be too simple and easy to simulate.
3. The signature should contain as many features as possible (slant, pen lift, tapering strokes, etc.).

The selected signature fulfilled the 3 conditions above in that it was neither very complicated nor very simple, the sequence of strokes was not difficult to decipher, and it contained a variety of features.

Preparation of the Survey Sheet

Known specimen signatures, comprising both normal and request specimens, were obtained from the writer of the selected signature. Among these, a representative signature was chosen to be the model for the participants to simulate (Figure 1). The model signature was scanned at original size and printed on plain paper to create the survey sheet.

Figure 1. The model signature used in this research.

Collection of Samples

Survey sheets were printed and distributed. The participants were instructed to simulate, to the best of their abilities, the model signature and to produce 5 attempts each in blue ballpoint ink in the space below the model signature on the same sheet provided. The participants were allowed to practice as much as they deemed necessary before attempting a simulation on the actual sheet. Sixty-two responses were received.

Checklist of Features for the Analysis

It would be difficult to include the entire list of possible features to be examined, as this was beyond the scope and timeline of this research project. It was decided, however, that a few representative characteristics would be selected and that more could be included in future work depending on the results of this study. Specific points were considered in the selection of the features:

1. They were picked to include many of the characteristics commonly noted in signature examination, such as letter formation, height relationships, tapering strokes, pen lifts, etc.
2. They were relatively unambiguous and easy to evaluate when judging whether participants performed satisfactorily or not.
3. There was a good spread of features with high, medium, and low levels of difficulty.

With the above criteria in mind, 12 characteristics were short-listed for the analysis (Figure 2), and an expected relative level of difficulty (ERLD) was assigned for each of them:

1. Starting "Hook" (ERLD – Medium)
   Refers to the subtle "hook" at the beginning (left) of the signature.

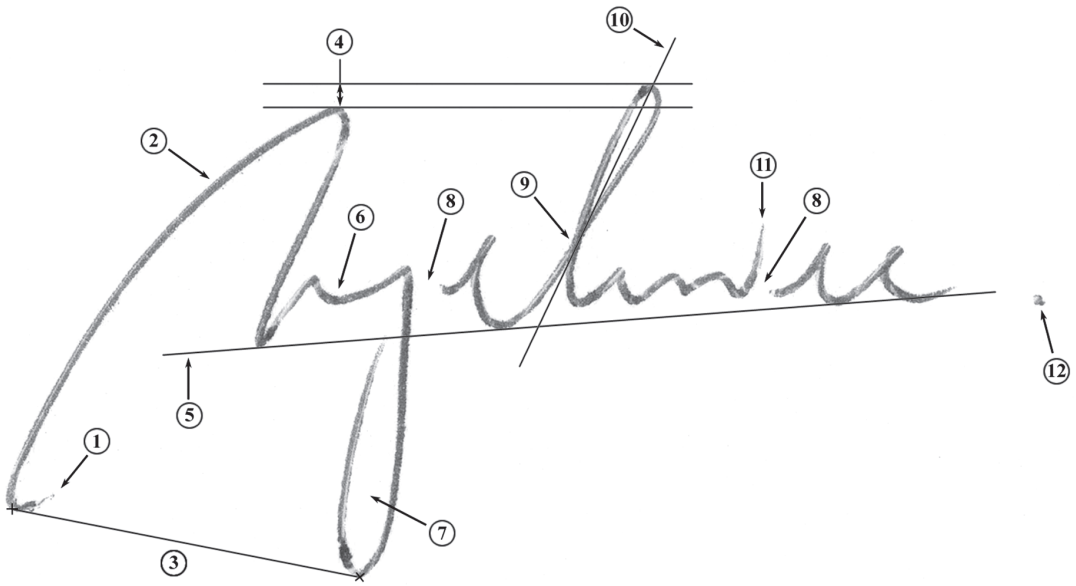

Figure 2. The 12 selected features of the model signature.

2. Curvature (ERLD – High)
   Refers to the formation of the starting curve with particular emphasis on its curvature.
3. Relative Position of the Curve and "y" (ERLD – Medium)
   Refers to the relative position of the bottom-most point of the starting curve with respect to the bottom of the loop of the adjacent "y"-like letter.
4. Relative Height of the Curve and "h" (ERLD – Medium)
   Refers to the relative height of the curve with respect to the "h"-like letter.
5. Baseline (ERLD – Medium)
   Refers to the baseline slope of the body of the signature.
6. "Valley" of "y" (ERLD – High)
   Refers to the formation of the comparatively wide and shallow "valley" of the "y"-like letter.
7. Shape of "y" Loop (ERLD – High)
   Refers to the formation of the descender (loop) of the "y"-like letter, with particular emphasis on its shape.
8. Pen Lift (ERLD – Low)
   Refers to the 2 areas at which there is a break in the signature.
9. Intersecting Point of "h" (ERLD – High)
   Refers to the point at which the staff of the "h"-like letter cuts the preceding connecting stroke.
10. Relative Slant of "h" to Baseline (ERLD – Medium)
    Refers to the slant of the "h"-like letter with respect to the baseline as shown.
11. Tapering of "w" (ERLD – Medium)
    Refers to the tapering off of the right upward stroke of the "w"-like letter.
12. Terminal Dot (ERLD – Low)
    Refers to the presence of the dot at the end of the signature.

The ERLD assignment was based on the team's knowledge and experience in signature examination. From past casework, it has been noted that there are certain features (e.g., large curves, loops) which are generally more difficult to simulate accurately than others. Since the writer's signatures were quite consistent with a narrow range of natural variation for the features selected, the ERLD for each feature was decided primarily in consideration of a balance of factors:

1. How obvious or subtle the feature was. (An inconspicuous feature not obviously visible would make an imitator's job more difficult

No.	Feature	Expected Relative Level of Difficulty	No. of Writers (Yes)	% Writers (Yes)
1	Starting "Hook"	Medium	20	33.3
2	Curvature	High	8	13.3
3	Relative Position of the Curve and "y"	Medium	17	28.3
4	Relative Height of the Curve and "h"	Medium	15	25.0
5	Baseline	Medium	13	21.7
6	"Valley" of "y"	High	2	3.3
7	Shape of "y" Loop	High	3	5.0
8	Pen-lift	Low	58	96.7
9	Intersecting Point of "h"	High	9	15.0
10	Relative Slant of "h" to Baseline	Medium	27	45.0
11	Tapering of "w"	Medium	22	36.7
12	Terminal Dot	Low	42	70.0

Table 1. Summary of results for the 60 participants.

because it would not be simulated in his/her attempt if it has not been observed in the first place.)

2. The number of points of reference in the feature. (Formations covering a bigger area contain more points of references; e.g., large curves or loops, making it harder for a person to control his/her hand movement to achieve an accurate simulation.)

For example, feature 8 (pen lift) was assigned a low level of difficulty because it is unambiguous, conspicuous, and easily imitable. On the other hand, feature 7 (shape of "y" loop) was assigned a high level of difficulty because the relatively large loop contains more points of reference. In addition, the descender of the "y" moves downward in a straight direction at first but shifts subtly into a very slight curve that is not so likely to be observed.

A checklist was then prepared and used to evaluate each of the 12 characteristics separately for each participant. If the participant was judged to have simulated a feature successfully in the majority of his/her 5 attempts, he/she was given a "yes" in the respective column. Conversely, if he/she could not simulate the feature satisfactorily, he/she was given a "no."

Results and Discussion

The summary of the results is shown in Table 1. The number of writers who managed to simulate each feature satisfactorily was added, and the percentage of these writers out of the total number of 60 participants was calculated. This total excludes the 2 participants who employed the tracing method.

General Observations

As expected, there was a general lack of fluency among most of the participants' attempts. Many of the simulations that were quite close in form to the model signature showed a visible lack of fluency, whereas those that were relatively fluent did not resemble the model signature as much (Figure 3). This was in line with common knowledge that when simulating another person's signature, one often has to make a choice between fluency and accuracy. Tipping the balance towards one would mean that the other had to be sacrificed.

In some of the attempts, there seemed to be a compromise in fluency in an effort to maintain the formation of the signature, but many of these simulations turned out to be poor in both accuracy and fluency (Figure 4).

With one exception, the participants who managed to simulate 7 or more of the 12 characteristics satisfactorily largely produced attempts that were visually not too different from the model signature in terms of general pictorial formation (Figure 5). The particular participant exception actually scored 8 out of 12, but the simulated signatures did not resemble the genuine signature in size and other features (Figure 6). This illustrates the point that the list of 12 features selected in this survey was far from being exhaustive. Even if a participant happened to get a perfect score (which none did), there were still numerous other characteristics to be evaluated, including but not

Figure 3. Example of one of the relatively fluent attempts at simulation at the expense of accuracy.

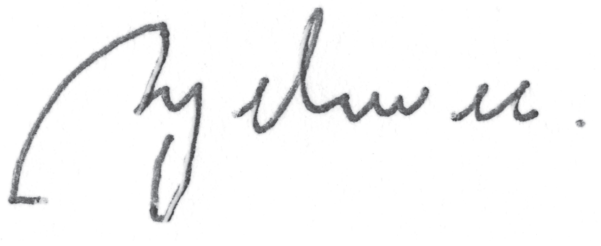

Figure 4. The majority of the 12 characteristics were incorrectly simulated in this attempt.

Figure 5. Example of one of the "high scoring" attempts that resembled the model signature in general pictorial formation.

Figure 6. Example of the "high scoring" attempt that was much smaller in size than the model signature.

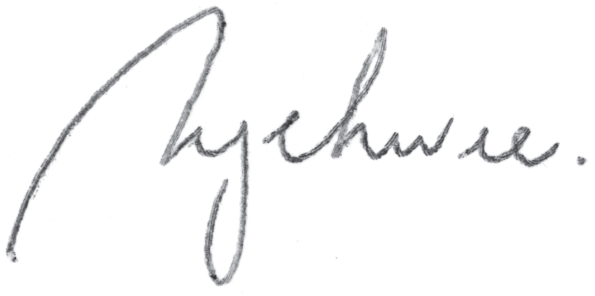

Figure 7. Example of one of the better attempts at simulation. However, a few features were not simulated correctly, such as the missing starting "hook," the incorrect height relationship between the curve and "h," and a lack of fluency.

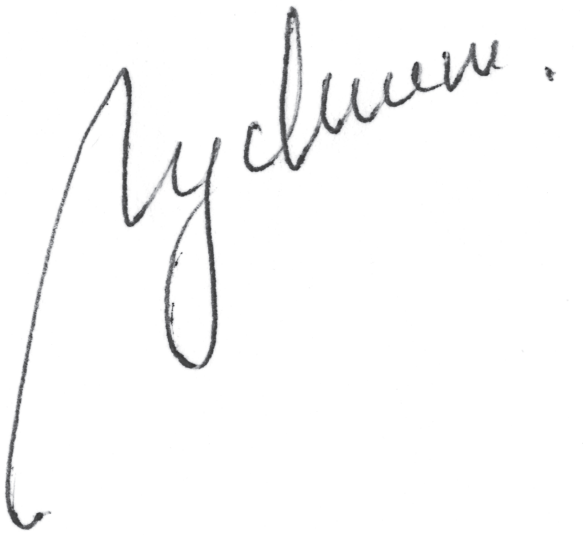

Figure 8. Example of a relatively fluent simulation attempt in which the writer's own characteristics were evident.

limited to stroke quality and fluency, formation of all the letters, and many more relative relationships.

Relative Levels of Difficulty

Based on the results obtained from the experimental data, the relative levels of difficulty of the different features studied were mostly in agreement with those expected. The 4 features (curvature, "valley" of "y," shape of "y" loop, and intersecting point of "h") that were rated high in the expected relative level of difficulty had the lowest percentage of writers, ranging from 3.3% to 15.0%, who managed a successful simulation. The 6 features (starting "hook," relative position of the curve and "y," relative height of the curve and "h," baseline, relative slant of "h" to baseline, and tapering of "w") that were rated medium had a percentage of success ranging between 21.7% and 45.0%. The 2 remaining features (pen lift and terminal dot) that were rated low in the expected level of difficulty had a success rate ranging from 70.0% to 96.7%. It must be emphasized that the relative levels of difficulty of simulation refer to the 12 chosen features *with respect to the model signature*. For example, a pen lift in another signature could be less conspicuous and hence would be rated as more difficult to simulate.

Point-By-Point Analysis

1. Starting "Hook" (33.3%)
   This feature was expected to have a medium relative level of difficulty, and results were in agreement. More than 60% of the participants could not manage the subtle hook. On one hand, the hook by some participants was too exaggerated and deliberate; whereas at the other end of the spectrum, it was completely absent in other participants' attempts (Figure 7).
2. Curvature (13.3%)
   The starting stroke was 1 of the more difficult features to imitate. As expected, more than 80% could not manage to simulate this feature successfully. Most of the attempts were either too sharp or too rounded, and some with the correct shape were marred by a kink in the curvature or a slight tremor.
3. Relative Position of the Curve and "y" (28.3%)
   Relative relationships are not easy to mimic in any signature. In this research, more than 70% of the participants had difficulty with relative relationships. Initially 3 points were chosen (2 on the curve and 1 on the "y"-like letter) as the reference points, but it proved to be rather difficult to judge consistently. Eventually, the number of reference points was reduced to 2, 1 on the curve and the other on "y."
4. Relative Height of the Curve and "h" (25.0%)
   More than 70% of the participants had difficulty with this feature. Although some participants noticed the height relationship difference, many were unable to translate the observation into their attempts and made the "h" shorter than the curve (Figure 7).
5. Baseline (21.7%)
   At first glance, the body of the signature appeared to have a consistently flat baseline. However, on closer examination, there was a dip at the end of the curve before the "y"-like letter and also a slight dip after the 1st pen lift, something which nearly 80% of the participants either failed to notice or could not simulate successfully.
6. "Valley" of "y" (3.3%)
   The relative level of difficulty of this feature was thought to be high, and nearly all the participants failed to simulate this feature satisfactorily. It appeared that most could not help introducing their own characteristics when writing the "y"-like letter (Figure 8).
7. Shape of "y" Loop (5.0%)
   Like the "valley" of "y" feature, nearly all the participants failed to simulate this feature satisfactorily. This was within expectations because of the feature's subtlety and the degree of skill required. Again, it appeared that most of the simulations contained some of the writers' personal characteristics when tackling this "y" loop (Figure 8).
8. Pen Lift (96.7%)
   This was one of the 2 relatively easy-to-simulate features. The results were in agreement with expectations. All but 2 of the participants had no problems with this characteristic. As the 2 pen lifts in this particular signature were easily noticed and imitated, participants who missed either pen lift were deemed to have failed in their attempt to reproduce this feature.

9. Intersecting Point of "h" (15.0%)

   This feature was expected to be difficult. The results were within expectations. The position of the intersection was a subtle point that many participants did not notice or failed to incorporate into their attempts.

10. Relative Slant of "h" to Baseline (45.0%)

    The relative level of difficulty of this feature was perceived to be medium, and the results were slightly better than expected. Nearly half of the participants managed to imitate this feature satisfactorily. Initially, the criterion for the angle of slant was set at ±5 °, but it was found to be too lenient; and the relative slant of "h" to the baseline of these "borderline" signatures deviated too much from the model. Eventually, it was revised to ±3 °.

11. Tapering of "w" (36.7%)

    Nearly 40% of the participants were observant enough to take note of this feature and successfully include it in their attempts. Tapering of certain strokes is not easily imitated, especially if it is not normally part of the participants' own handwriting or signatures or if the tendency is different. On the other hand, if it happens to be part of their normal handwriting or signatures, it is expected that these participants should not face too much difficulty as long as they put in some effort.

12. Terminal Dot (70.0%)

    This was 1 of the 2 features with a relatively low level of difficulty; however, the results were somewhat surprising. Only slightly more than 2/3 managed to pass. In normal casework, it is not just the presence or absence of the terminal dot that is important but also, among others, the position, pen pressure, and shape of the dot if present in a signature. To make it easy to judge and also to include a relatively easy-to-simulate feature in this exercise, participants only needed to make sure that the terminal dot was present in their attempts. It was expected that almost all would be able to get this feature correct, so the result of 70% was somewhat below expectations. Perhaps it was due to sheer carelessness, lack of effort, or an inability to perceive details.

Problems / Improvements / Modifications

Despite instructions given to the participants to simulate to the best of their abilities the model signature and to produce 5 attempts each in blue ballpoint ink, the following problems were encountered:

1. Traced Signatures

   Two participants completed the exercise by tracing. (Suspected traced attempts were confirmed with the respective participants.) These sheets were removed and not used in this study. Among the traced attempts, 1 participant was proven to have quite a steady hand. Unlike many traced forgeries, there were relatively few obvious signs of hesitation, retouching, or tremors. However, under the microscope, some discrepancy and tremor could be detected. The fact that all 5 attempts were very nearly identical to one another was another telltale sign that the tracing method had been used.

2. Fewer or More than 5 Attempts

   Twenty participants did not adhere to the "5 attempts" instruction. One participant produced only 1 signature, whereas some zealous participants provided 10 or more. After discussion among the team, it was decided that all attempts, regardless of the total number of signatures provided, would be taken into consideration, with application of the "majority wins" rule across the board.

3. Did Not Use Ballpoint Pen

   Some participants did not use a ballpoint pen. However, as this did not affect the analysis, those attempts written with roller/gel/felt pens were treated and analyzed the same way as their counterparts written with ballpoint ink.

4. Did Not Use Blue Ink

   Some participants used black ink instead of the instructed blue ink. Again, as with the instruction regarding ballpoint pen, this was not of utmost importance and did not affect the analysis, so the black inked signatures were accepted. Blue ink was indicated in an attempt to reduce the number of variables to a minimum.

To minimize the above problems in future work, it would be necessary to provide very clear, concise, written instructions on the survey sheet and to go through these instructions with the

participants to make sure that they were clearly understood.

Conclusions

Results show that the experimental data is generally in agreement with the expected relative levels of difficulty of the characteristics studied. This in turn provides good evidence that the principles and knowledge applied in forensic handwriting and signature examinations are sound and reliable and that characteristics in a person's signature are individualized.

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