

A Study of Attempted Simulated Signatures by Teenage Writers

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The authors Harrison, Hilton, Huber and Headrick, and Osborn defined characteristics of simulation. Based on the written works of these authors, a study was conducted using 19 categories of reported characteristics of simulation. Attempted simulated signatures were obtained from 106 teenage writer participants and the results examined for 1 or more of the 19 simulation characteristics. This study supports the recorded works by these noted authors pertaining to characteristics of simulation.

Introduction

Although a number of studies have been done pertaining to simulations, such as in the papers by Muehlberger (1989) and Lee, et al. (2006), this study concentrates on the oft-referenced books by forensic document examiners Harrison (1966), Hilton (1982), Huber and Headrick (1999), and Osborn (1929), hereafter referred to as the "authors." These authors cite features of handwriting that should be examined to determine if a freehand simulation was prepared. The characteristics of simulation include tremor in the writing line, pen lifts, and blunt beginning and ending strokes. However, they suggest that there are other indicators of simulation.

Harrison (pp. 400-405) described line quality, line endings, pen lifts, retouching, and shading as features that will bear indications of simulation. Headrick and Huber (p. 291) and Hilton (p. 185) suggest that the characteristics of freehand simulations include "hesitation, unnatural pen lifts, patching, tremor, abrupt changes in line direction, and drawn line quality...combine to reveal the true nature of the spurious simulation of a signature." Osborn (pp. 288-291) has an extensive list of 54 "features of importance" broken down to *general features, movement or manner of writing, pen pressure and shading*, and *special features* that indicate a simulated signature.

From the writings of these authors, 19 characteristics of simulation were identified as characteristics that were worth noting in the examination of signatures to determine the

naturalness of a questioned signature. The characteristics were pen lifts, practice or correction attempts, baseline habits, skill, speed and movement, abrupt changes in direction, line quality, pen pressure, i/j-dots, t-crossing and punctuation, width, capital letters, proportions, slant, connecting strokes, descenders, ascenders, ending strokes, and blunt beginning and ending strokes. Examinations and comparisons of the questioned and known signatures were conducted to determine if the characteristics that the authors described were present in the unpracticed simulation attempts by teenage writers.

Methods and Materials

Teenage writers numbering 106 participated in the study. These writers were between the ages of 16 and 19 and attended the same college preparatory high school. The participants were asked to write their signatures 3 times on a piece of paper, switch the paper with their signatures with another classmate, and then simulate the signatures on the papers they received. No instructions were given on how to simulate a signature or what any of the characteristics of simulations are. The samples of simulations were taken from the participants. The comparisons were made between the known writer, herein described as the "writer," and the person attempting the simulation, herein described as the "simulator."

Examinations of the questioned and known signatures were conducted following the American Society of Testing and Materials (ASTM) International Standard Guide for the Examination of



Figure 1. Example of a simulation showing patching at the top of the “J” and overwriting in the “a.” Pen lifts were found in every letter of this simulation attempt.

Handwritten Items (2003). The questioned and known signatures were examined visually and microscopically to determine their characteristics. The questioned signatures were evaluated for the 19 criteria suggested by the authors and charted accordingly.

Results and Discussion

The characteristics of simulation as defined by the authors and used in this study are listed, along with the results of the examination of each characteristic.

Pen Lifts

The authors report that additional pen lifts are often characteristic of freehand simulations. According to Huber and Headrick (p. 406), pen lifts are “an interruption in a stroke due to the removal of the writing instrument from the paper.” In the study of the teenage simulators, all but 5 of the simulators had more pen lifts in the simulation than were in the habits of the writers. The 5 simulators who did not have additional pen lifts in their simulation attempts were able to follow the pattern of the known signatures without lifting the pen in places other than where the writer had pen lifts as part of their signatures. None of the simulators used fewer pen lifts than the writers. In the 101 samples that bore additional pen lifts, the majority of the simulators, 62%, used between 1 and 3 pen lifts, with the majority of those (34) using 3 pen lifts. Although the pen lifts ranged between zero and 11 in the simulations, the average number of pen lifts was 3.5 per attempt. For the simulators that used 4 or more pen lifts, at least 1 of the pen lifts was found in connecting strokes.

Practice or Corrections

Some of the simulators used false starts, erasing and/or patching, and overwriting in their attempts. In the majority of this category, the simulations bore patches. Huber and Headrick (p. 406) define patching as “retouching or going over a defective portion of the writing stroke.” In this study, 60% of the simulators used patching and/or overwriting. In some of the simulations, the patching and overwriting were significant throughout the attempt. In the 1st initial of the first name, 25 simulators used patching, while 16 simulators used patching in the initial of the last name and 13 simulators used patching in both. Only 4 simulators used patching in the ending stroke of the last name. Seven simulators were found to have false starts in their attempts, and 4 of these did not overwrite in their next attempt. Another 4 simulators erased portions of their attempts and used patching and overwriting. It was interesting to note that 3 simulators did not finish the whole signature.

Baseline

Hilton defines baseline as “the ruled or imaginary line upon which the writing rests” (p. 18). The majority of the samples were prepared on ruled paper. Only 2 writers used nonruled paper. These simulations were examined to determine how they compared with the writers’ baseline habits at the start, the middle, and the ending of their names. Only 28% of the simulators were able to reproduce the baseline habits of the writers. Twenty-four, or 23%, of the simulations had baseline differences in the middle of the signatures—either higher or lower than the baseline of the writers. For those simulators who started at a similar baseline to the known signatures, 13 ended the signatures lower than the writers, and 11 ended the signatures higher than the writers. The other simulations ranged in baseline habits from being higher above the baseline to lower than the baseline of the writers. Some of these simulations were mixed baselines; i.e., both higher and lower than the baseline habits of the writers.

Skill of the Simulator

Hilton (p. 185) wrote, “Failure often results because the forger has only a superficial idea of a few characteristics of both his own writing and the writing to be simulated or because his skill as a penman fails to measure up to that of the person whose writing is being imitated.”

	Simulators		
	Majority Tremor	Partial Tremor	Very Little Tremor
More pressure than writers	23	13	6
More pressure than writers	23	13	2 6
Less pressure than writers	28	11	2 2
Less pressure than writers	28	11	2 2
Same pressure as writers	17	4	2

Table 1. Comparison of the tremor in simulations with the pressure used by the writers.

Simulations are attempts to imitate a writer's characteristics. To be successful, the simulator must forego his/her natural handwriting habits and skills to imitate the handwriting habits of the writer. The simulator's actual writing skill may be masked by the attempt to imitate or draw the handwriting of the writer. In this study, the handwriting skill could not be determined in 48% of the simulations because there was an insufficient amount of natural handwriting with which a determination could be made. In 37% of the simulations, the simulators appeared to have similar skill to the writers. Thirteen percent of the simulators appeared to have better skill than the writers.

Speed and Movement

Regarding speed and movement, Osborn (p. 106) wrote, "These descriptions are necessarily of a general character but are of value in so far as they assist in calling attention to every element of the writing habit." In Osborn's discussion of handwriting skill, he writes that the speed of the writing can be broken down into 4 categories—slow and drawn, deliberate, average, and rapid. The simulations were examined, and it was found that 51% were assessed as deliberate, while 37% were assessed as slow and drawn. Only 2 simulations were rapidly written.

Abrupt Changes in Stroke Direction

Hilton (p. 185) describes 1 characteristic of simulations as "uncertainty of movement as portrayed by abrupt changes in the direction of the line." The simulations were assessed for abrupt direction changes that were not part of the design of the known signatures. One-half (50%) of the simulations bore these changes. Of 53 simulators, 25 executed more than 1 abrupt change in their

simulation attempts. The majority of the simulators (31 out of 53) made the abrupt changes in the connecting strokes.

Line Quality

According to Huber and Headrick (p. 404), line quality is "the degree of regularity (i.e., smoothness and/or gradation) to the written stroke as may be judged from the consistency of its nature and of its path in a prescribed direction. It varies from smooth and controlled to tremulous and erratic." All of the simulations (100%) in this study bore some tremor. In the majority of the simulations, 64%, tremor was found throughout the simulation. Twenty-six percent of the simulators had tremor in less than half of their simulation attempts. Very small areas of tremor were found in 9% of the simulators' attempts—such as in the downstroke of a descender. The attempts of this 9% were assessed to have average or rapid writing speed. In addition, these simulators had no more than 3 pen lifts in their attempts. Where tremor was found in parts of the simulators' writings, 22 out of the 27 were assessed as writing with deliberate speed. None was judged to have rapid writing, and those simulations that contained tremor throughout the signature were assessed as having slow and drawn or deliberate writing speed.

Pen Pressure

Hilton (p. 20) describes pen pressure as "the average force with which the pen contacts the paper, as estimated from an examination of the writing." Pen pressure was compared between the known signatures and the simulations. More pen pressure was used in the simulations than in the known signatures by 40% of the simulators. Less pen pressure was used in the simulation by 39%

of the simulators. About 22% of the simulators used a similar amount of pen pressure as the writers. In the comparison of the line quality and the pen pressure used in the simulation attempts, there were mixed results (Table 1).

Missing Strokes/Added Strokes/Misspellings

In this study, there were some simulations that had missing strokes, added strokes, and/or misspellings. One or more of these features were found in 28 simulations, and 6 of these had more than 1 mistake. In addition, 13 of the 28 had a missing stroke, while 11 had an added stroke. Misspellings were found in 7 simulations.

Punctuation (including t-crossings and i/j-dots)

With regard to simulations, Osborn (p. 290) recommends that all the details of the writing get attention, including "t crossings and i dots: location, shape direction and care." In this study, 40 writers used at least 1 lower case "t" in their names. In 3 of the simulations, the t-crossings were missing. In 4 of the simulations, the t-crossings were significantly shorter than in those of the writer; while in 10 simulations (25%), the t-crossings had longer crossbars. Seventy-six writer names contained lower case letters "i" and/or "j." In 13 of the simulations, the dots were missing from these letters. In 3 simulations, i/j-dots were added even though the writers did not use them. Five simulations had i/j-dots different from the dot(s) used by the writers. Of the 8 writers who used middle initials, 6 placed periods after their middle initials. In the simulations, only 1 simulator did not use the period after the middle initial. Two writers used the suffix "Jr." with a period but no comma between the last name and the suffix. It was noted that 1 simulator did not use the period after "Jr."

Width of Signatures

Osborn (p. 290) recommends that the width of the writing be determined and spacing between the capital and small letters be evaluated. In the comparison between the known signatures and the simulations, the width of the signatures was measured. The majority of the simulations, 66%, were wider than the known signatures. The simulations that were wider than the writers averaged a +.8 cm difference. In the simulations that were not as wide as the known signatures, the simulations averaged -.6 cm shorter than the writers' signatures. Only 5 simulators were able to duplicate the width of the writers.

Capital Letters

Referring to capital letters, Osborn (p. 107) wrote, "Two very significant parts of a signature, or any writing under investigation, are the last strokes of the words and separate capital letters." Mistakes in the production of the capital letters were made by 83% of the simulators. These mistakes included differences in letter design, size, slant, incorrect proportions, and/or patching, and overwriting. Of these simulators, 65% made mistakes in all the capital letters in the names. The heights of the capital letters in the writers' signatures were measured and compared to the heights of the capital letters in the simulations. The results were mixed, with 43% of the simulators using shorter capital letters than the writers. The average difference between the writers' capitals and the shorter capitals by the simulators was -.2 cm. Of the simulators that used capital letters taller than those used in the writers (31%), the difference between the height of the simulation and known signatures was +.25 cm. In 25% of the simulations, there were no measurable differences noted. However, it should be noted that all but 2 of the samples were prepared using lined paper, and most writers and simulators limited themselves to the ruling on the paper.

Proportion

Osborn (p. 289) also recommends that the "proportions of individual letters to each other, proportions of parts of the same word" be compared. In this study, the proportions of the various parts of the signatures were measured and compared. These proportions were measured intra- (within), and inter- (between) capital letters, lower case to upper case letters, and intra- and inter-lower case letters (Table 2). Only 2 simulators were able to duplicate all the proportions (height ratios) of the known writers. Thirty-eight simulators could not duplicate any of the proportions by the writers. The remaining simulators had a mix of proportions.

Slant

Hilton (p. 21) defines slant as "the angle or inclination of the axis of letters relative to the baseline." The slants of the simulations and writer signatures were compared and evaluated to determine the predominate slants (Figure 2). The types of slants used by the writers were 67 right, 35 upright, 3 left, and 1 mixed. The slant of the known signature was compared to the slant of the simulation (Table 3).

<u>Intra-caps</u>	<u>Inter-caps</u>	<u>Small to Caps</u>	<u>Intra-Small</u>	<u>Inter-Small</u>
83%	62%	65%	75%	73%

Table 2. Percentage of letter proportion (height ratio) errors within the simulation attempts.

<u>Simulators</u>	<u>Writers</u>			
	<u>Right Slant</u>	<u>Upright</u>	<u>Left Slant</u>	<u>Mixed Slant</u>
Right Slant	55	7	0	1
Upright	9	26	2	0
Left Slant	1	1	0	0
Mixed Slant	2	1	1	0

Table 3. Comparison of slant between the writer signatures and simulator signatures.

Connecting Strokes

As to connecting strokes, Harrison (p. 321) wrote, "Whenever there is reason to suspect that a handwriting is a copy, the connecting strokes will amply repay close investigation. Almost invariably it will be found that whilst the copyist may have succeeded in reproducing the more obvious features of letter design, little care has been taken to introduce connecting strokes which will pass muster." The connecting strokes of the simulations were examined. It should be noted that 1 writer used a hand-printed signature with no connecting strokes. Of the 105 simulations that contained connecting strokes, 103 had flaws in the connecting strokes. Of these flaws, the majority of the simulators, 84%, had both pen lifts and line quality problems in their connecting strokes. Some of the other flaws included added or missing connecting strokes, spacing and proportion differences, and/or design differences.

Descenders

Huber and Headrick (p. 398) described "descender" as a "part of a letter extending below the base line." In this study, 71 writers used at least 1 of the descenders in the letters f, g, J, j, p, q, y, and z in their signatures. Their habits of slant, length, and width of their descenders were evaluated and compared to the simulations. Eleven simulators were able to reproduce the slant of the descenders of the known writers. The slant

of the descenders was more upright in 46% of the simulations, and 38% of the simulators made the slant of the descenders more acute than the known writers. In the width of the descenders, 41% of the simulators were able to reproduce the width of the descenders of the writers. Thirty-two percent of the simulators made their descenders wider by no more than .2 cm than the writers. The remaining 27% of the simulators made the descenders narrower than in the writers' signatures. Most simulators could not duplicate the length of the writers' descenders (Figure 3). Only 17% of the simulations duplicated the length of the writers' descenders. Forty-five percent of the simulators used shorter descenders than writers. Most of these, 22, were approximately 0.1 cm shorter than the writers' descenders. Twenty-one simulators were able to reproduce the writers' descenders within a 5 degree slant, with ± 0.1 cm difference in both the width and length. None of the simulators was able to reproduce the exact slant, width, and length of the writers' descenders.

Ascenders

Huber and Headrick (p. 395) describe "ascender" as "part of the lowercase letters extending above the body or x-height. In this study, 87 writers used letters with ascenders in the letters b, d, f, h, k, l, and t in their signatures. Their habits of slant, length, and width of their ascenders were

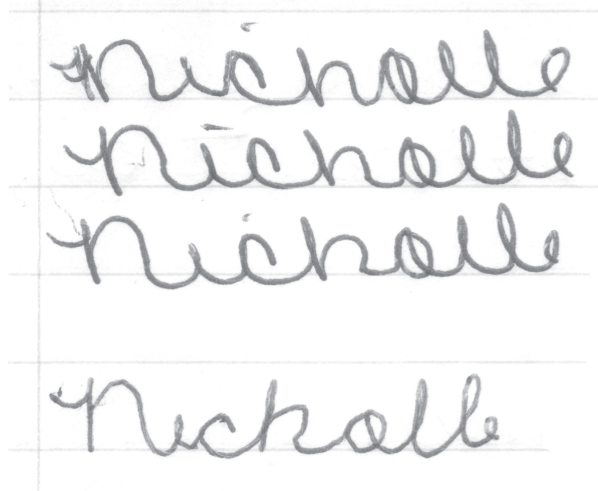


Figure 2. The first 3 writer signatures clearly contain a left slant; however, the simulator was unable to reproduce this slant in the 4th signature down.

evaluated and compared to the simulations. Fourteen simulators were able to reproduce the slant of the ascenders in the writers' signatures. Thirty-eight percent of the simulators used a more acute slant of the ascenders than was used in the knowns. In the width of the ascenders, 74% of the simulators duplicated the width of the writers' signatures. Most of the other width differences between the simulations and the knowns were within ± 0.2 cm. An equal amount of simulators, 23 each, had the correct height of the ascenders or were approximately $+0.1$ cm taller than similar ascenders in the knowns. Twenty-six simulators used shorter ascenders than were found in the knowns. Thirty-six simulators were able to reproduce the ascenders in their attempts within a 5 degree slant with ± 0.1 cm difference in both the width and length of the writers' ascenders. Only 1 simulator was able to reproduce the exact slant, width, and length of the writer's ascender.

Ending Strokes

Huber and Headrick (p. 289) wrote that "the task of sustaining a good simulation is more difficult the longer the signature." An examination of the ending strokes of the questioned signatures was conducted. Eighty-seven percent of the simulators made mistakes in the ending strokes of their attempts, the majority of which were in the design of the ending strokes. Of the simulators that incorrectly designed the ending strokes, 71% had mistakes in the ending strokes in both the first and last names.

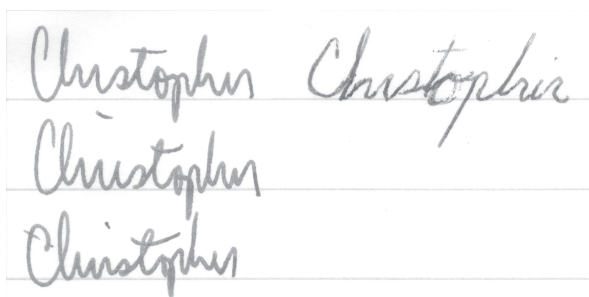


Figure 3. Example of differences in length and slant of the descender between the writer's signature (left) and the simulation attempt (right).

Blunt Beginning and Ending Strokes

Regarding blunt beginning and ending strokes, Harrison (p. 401) wrote, "With a carefully written forgery the pen usually has to be deliberately placed on the paper at the desired position before any appreciable motion is imparted to it. When each pen movement is complete, a forger will often allow his pen to rest momentarily on the paper while he takes stock of the position. Under these conditions, the ends of the ink line in a forgery tend to be thickened rather than tapered." The authors recognized the movement of the pen across the paper and the trail of ink that ensues. When a writing instrument is in motion before it hits or leaves the paper, it deposits a trail of ink or graphite that is tapered. When the writing instrument is put to the paper and then moved or the writing is stopped abruptly, the result is a blunt beginning or ending stroke. This feature of the writers and the simulators was examined and evaluated for the quality of the beginning and ending strokes as *tapered*, *blunt*, or *cannot determine* (Table 4).

In some known signatures and simulations, the first and last names were connected so that the end of the first name and the beginning of the last name did not have beginning and ending strokes. These signatures/simulations were not counted. Also not counted were 3 simulations in which the last names were not completed. Seventeen simulators had blunt beginning and ending strokes in both names. None of these matched the pattern of blunt and tapered strokes of the

	<u>Tapered</u>	<u>Blunt</u>	<u>Cannot Determine</u>
Beginning of 1st name in K	81	19	6
Ending of 1st name in K	91	11	1
Beginning of last name in K	82	19	
Ending of last name in K	94	12	
Beginning of 1st name in Q	32	65	9
Ending of 1st name in Q	44	60	
Beginning of last name in Q	43	54	6
Ending of last name in Q	50	54	

Table 4. Table of usage of blunt and tapered beginning and ending strokes by the writers (K) and the simulators (Q).

writers. Nine simulators used all tapered beginning and ending strokes, 5 of which matched the pattern of the writers.

Conclusions

The majority of the 106 teenage participants in this study were found to have between 10 and 14 characteristics of simulation in their attempts. In the 19 extrapolated categories of characteristics described by authors Harrison, Hilton, Huber and Headrick, and Osborn (Appendix 1), the majority of the simulators averaged errors in 11.8 categories. Although 2 simulators executed mistakes in 17 categories, no simulator had mistakes in all 19 categories. One simulator was found to have mistakes in only 5 categories; however, these mistakes were significant, especially in the areas of pen lifts, line quality, movement, and pen pressure. This simulator was able to replicate all of the other characteristics of the known writer. None of the simulators made the exact same errors as another simulator in their attempts.

This study of the simulation attempts by teenage writers validates at least 19 characteristics of simulation as described by the authors. There is the possibility that other characteristics of simulation may be present in any simulation attempt, such as pictorial similarities and letter construction. It should be noted that the attempted simulations by the teenage participants were unpracticed simulations by writers with no motivation for success in their attempts.

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Appendix 1.

Summary of Simulation Characteristics and Percentage

1. *Pen Lifts* 95% of the simulators executed more pen lifts in the simulation than the writers.
2. *Practice or Correction Attempts*
60% of the simulators used patching or overwriting in their attempts.
10% of the simulators used either an erasure or a false start.
3. *Baseline* 72% of the simulators were not able to follow the baseline habits of the writers.
4. *Skill* 37% of the simulators had similar skill to the writers.
48% of the simulators' skill levels could not be determined.
5. *Speed* 88% of the simulators used movements that were slow and drawn or deliberate.
6. *Abrupt Changes in Direction*
50% of the simulators used abrupt direction changes in their attempts that were not part of the design of the writer signatures.
7. *Line Quality* 100% of the simulations had some area of poor line quality.
8. *Pen Pressure* 40% of the simulations contained more pen pressure than was found in the writer signatures.
22% of the simulators used approximately the same amount of pen pressure as found in the signatures of the writers.
9. *Missing Strokes, Added Strokes, Misspellings*
26% of the simulators had a missing stroke(s), added stroke(s), and/or a misspelling in their attempts.
10. *Punctuation (including i/j-dots and t-crossings)*
40% of the simulators made mistakes in at least 1 of the "i," "j," or "t" letter forms or in punctuation.
11. *Width of Signatures*
66% of the simulations were wider than the writer signatures.
12. *Capital Letters* 83% of the simulators made mistakes in the design, size, slant, proportions, and/or used patching and overwriting of the capital letters.
43% of the simulators used shorter capital letters than were found in the knowns.
25% of the simulators were able to replicate the size of the capital letters.
13. *Proportions* 98% of the simulators were not able to closely replicate all of the proportions of the writer signatures.
14. *Slant* 76% of the simulators duplicated the slant of the writers.
15. *Connecting Strokes*
98% of the simulations had differences from the writer signatures in the connecting stroke(s). These differences were in line quality and/or pen lifts.
16. *Descenders* 100% of the simulators could not reproduce the exact slant, width, and length of the descender(s) in the writers.
30% of the simulations that bore descenders could be reproduced similar to the writers' descenders (within 5 degree difference in slant and ± 0.1 cm difference in width and length).

17. *Ascenders* 41% of the simulators could reproduce ascenders that were similar (within 5 degree difference in slant and ± 0.1 cm in height and width) to the writers. Only 1 simulator was able to replicate the slant, height, and width of the writer's ascenders.
18. *Ending Strokes* 87% of the simulators made mistakes in the ending stroke(s) of the signatures.
19. *Blunt Beginning and Ending Strokes* 94% of the simulators did not duplicate the pattern of blunt and tapered beginning and ending strokes of the writers.