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A Statistical Examination of Selected Handwriting Characteristics

The handwriting identification facet of questioned document examination suffers from the lack of statistical data concerning the frequency of occurrence of combinations of particular handwriting characteristics. While document examiners tend to assign probative values to specific handwriting characteristics and their combinations, judgments are often based almost entirely on the examiner's experience and power of recall. Since handwriting identification is a scientific pursuit, statistical data concerning frequency of occurrence of forms and combinations would seem to offer some promise for providing a basis for the opinions of document examiners.

This paper details the results of a research study conducted at the Georgetown University Forensic Sciences Laboratory, Washington, D.C., under the direction of Mr. Joseph M. English. The statistical data included is not intended to provide a substitute for proper training and experience of the document examiner. Rather, it is offered as a compilation of data from the population surveyed to supplement the practical experience of the document examiner.

Because of its continual reappearance in handwritten documents in the English language, the "th" combination was selected for study. The experiment was limited to the examination of initial "th" combinations in words but encompassed both requested and nonrequested writings of 200 individuals. One hundred requested exemplars were obtained by the researchers on a standard 8 by 10-in. (20 by 25-cm) handwriting form. Four initial "th" combinations, in the words "that," "this," and "the" were examined and classified by five co-researchers on 20 Feb. 1975. On 25 Feb. 1975, four initial "th" combinations, only in the word "the," were examined in 100 nonrequested writings by four co-researchers.

Classification was done according to six characteristics of the "th" combination. Each of the six characteristics was assigned an identifying number from 1 to 6, and each category within the characteristic was given an identifying lower-case letter. The code number and letter designations were established as follows:

- (1) height relationship of the "t" to the "h": (a) "t" shorter than "h," (b) "t" even with "h," (c) "t" taller than "h," and (d) no set pattern;
- (2) shape of loop of the "h": (a) retraced, (b) curved right side and straight left side, (c) curved left side and straight right side, (d) both sides curved, and (e) no fixed pattern;

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- (3) shape of the arch of the "h": (a) rounded arch, (b) pointed arch, and (c) no set pattern;
- (4) height of cross on "t" staff: (a) upper half of staff, (b) lower half of staff, (c) above staff, and (d) no fixed pattern;
- (5) baseline of the "h": (a) slanting upward, (b) slanting downward, (c) baseline even, and (d) no set pattern; and
- (6) shape of the "t": (a) tented, (b) single-stroke, (c) looped, (d) closed, and (e) mixture of shapes.

The raw data were to be combined after the examination by the co-researchers. For this reason, the categories were specifically diagrammed and instructions were standardized. Each characteristic contained a category labeled "no set pattern" or "mixture." Because four "th" combinations written by each individual writer were examined, at least three of any one type had to have been present for it to fit into an identifying category. If this condition was not met, the letter form was categorized "no set pattern" or "mixture." The raw data were then assembled according to numerical and percentage values (Table 1).

The next step taken in the project was the consideration of each characteristic as it related to the others. Characteristics which were believed to be most related in letter

TABLE 1—Data for 200 handwriting samples compiled according to percentage values. Actual number of writers is shown in parentheses.

1. Height relationship of the "t" to the "h":
 - a. 78% (156) made "t" shorter than "h"
 - b. 1.5% (3) made "t" even with "h"
 - c. 5.5% (11) made "t" taller than "h"
 - d. 15% (30) no set pattern
2. Shape of the loop of the "h":
 - a. 27.5% (55) made retraced staff
 - b. 32% (64) made loop with curved right side and straight left
 - c. 2.5% (5) made loop with curved left side and straight right
 - d. 17% (34) made a loop with both sides curved
 - e. 21% (42) had no fixed pattern
3. Shape of the arch of the "h":
 - a. 18% (36) made rounded arch
 - b. 66% (132) made pointed arch
 - c. 16% (32) made arch with no set pattern
4. Height of cross on "t" staff:
 - a. 71.5% (143) made cross in upper half of staff
 - b. 10.5% (21) made cross in lower half of staff
 - c. 1% (2) made cross above staff
 - d. 17% (34) made cross with no fixed pattern
5. Baseline of the "h":
 - a. 37.5% (75) made baseline slanting upward
 - b. 11% (22) made baseline slanting downward
 - c. 10.5% (21) made baseline even
 - d. 41% (82) had no set pattern
6. Shape of the "t":
 - a. 1.5% (3) made tented "t"
 - b. 32% (64) made single stroke "t"
 - c. 14% (28) made looped "t"
 - d. 31.5% (63) made closed "t"
 - e. 21% (42) made a mixture of "t" shapes

formation and stroke direction were cross tabulated. Each cross tabulation details dual correlations in both numerical and percentage values and provides one example of the data gathering method (Tables 2-7).

TABLE 2—Characteristic 1: height relationship of the "i" to the "h" for a total of 200 samples.*

Samples	2a	2b	2c	2d	2e	4a	4b	4c	4d	6a	6b	6c	6d	6e
Incidence of "i" shorter than "h" (1a)														
Number	156	36	57	27	32	115	12	2	27	3	44	20	55	34
Percentage	78	23.1	36.5	17.3	20.5	73.7	7.7	1.3	17.3	1.9	28.2	12.8	35.2	21.8
Incidence of "i" even with "h" (1b)														
Number	3	2	0	0	1	3	0	0	0	0	2	1	0	0
Percentage	1.5	66.6	0	0	33.3	100	0	0	0	0	66.6	33.3	0	0
Incidence of "i" taller than "h" (1c)														
Number	11	5	1	2	3	8	3	0	0	0	6	1	2	2
Percentage	5.5	45.5	9.1	18.2	27.3	72.7	27.3	0	0	0	54.5	9.1	18.2	18.2
Incidence of no set pattern (1d)														
Number	30	12	6	1	5	17	6	0	7	0	12	6	6	6
Percentage	15	40	20	3.3	16.7	56.7	20	0	23.3	0	40	20	20	20

*Code numbers and letters are explained in the text. A sample reading of the table is this: of the 11 people making "i" taller than "h," 8 crossed "i" in upper half of staff (72.7%) and 6 made a single-stroke "i" (54.5%).

*Code numbers and letters are explained in the text. A sample reading of the table is this: of the 11 people making "i" taller than "h," 8 crossed "i" in upper half of staff (72.7%) and 6 made a single-stroke "i" (54.5%).

TABLE 3—Characteristic 2: Shape of the loop of the "h" for a total of 200 samples.*

Samples	3a	3b	3c	5a	5b	5c	5d
Incidence of retraced "li" loop (2a)							
Number	7	41	7	23	4	6	22
Percentage	12.7	74.5	12.7	41.8	7.3	10.9	40
Incidence of curved right side, straight left (2b)							
Number	17	42	5	22	7	8	27
Percentage	26.6	65.6	7.8	34.4	10.9	12.5	42.2
Incidence of curved left side, straight right (2c)							
Number	1	4	0	3	2	0	0
Percentage	20	80	0	60	40	0	0
Incidence of both sides curved (2d)							
Number	6	24	4	13	5	4	12
Percentage	17.6	70.6	11.8	38.2	14.7	11.8	35.3
Incidence of no set pattern (2e)							
Number	5	21	16	14	4	3	21
Percentage	11.9	50	38.1	33.4	9.5	7.1	50

*Code numbers and letters are explained in the text. A sample reading of the table is this: of the 34 people making both sides of "h" loop curved, 24 made pointed arch of "h" (70.6%) and 13 made baseline of "h" slanting upwards (38.2%).

TABLE 4—Characteristic 3: shape of the arch of the "h" for a total of 200 samples.*

	Samples	2a	2b	2c	2d	2e	5a	5b	5c	5d	6a	6b	6c	6d	6e
Incidence of rounded arch of "h" (3a)															
Number	36	7	17	1	6	5	13	3	8	12	0	14	3	13	6
Percentage	18	19.4	47.2	2.8	16.7	13.9	36.1	8.3	22.2	33.3	0	38.9	8.3	36.1	16.7
Incidence of pointed arch of "h" (3b)															
Number	132	41	42	4	24	21	52	15	12	53	3	42	20	40	27
Percentage	66	31.1	31.8	3.03	18.2	15.9	39.4	11.4	9.1	40.2	2.3	31.8	15.2	30.3	20.5
Incidence of no set pattern (3c)															
Number	32	7	5	0	4	16	10	4	1	17	0	8	5	10	9
Percentage	16	21.9	15.6	0	12.5	50	31.3	12.5	3.1	53.1	0	25	15.6	31.3	28.1

*Code numbers and letters are explained in the text. A sample reading of the table is this: of the 36 people making a rounded arch of the "h," 14 made a single-stroke "h" (38.9%) and 13 made a closed "h" (36.1%).

TABLE 5—Characteristic 4: height of the cross on the "t" shaft for a total of 200 samples.

	Samples	1a	1b	1c	1d	2a	2b	2c	2d	2e	6a	6b	6c	6d	6e
Incidence of cross in upper half (4a)															
Number	143	115	3	8	17	44	46	4	22	28	3	40	22	47	31
Percentage	71.5	80.4	2.1	5.6	11.9	30.8	32.2	2.8	15.4	19.6	2.1	28	15.4	32.9	21.7
Incidence of cross in lower half (4b)															
Number	21	12	0	3	6	5	6	0	4	6	0	12	3	4	2
Percentage	10.5	57.1	0	14.3	28.6	23.8	28.6	0	19	28.6	0	57.1	14.3	19	9.5
Incidence of cross above staff (4c)															
Number	2	2	0	0	0	0	2	0	0	0	0	0	0	1	1
Percentage	1	100	0	0	0	0	100	0	0	0	0	0	0	50	50
Incidence of no set pattern (4d)															
Number	34	27	0	0	7	6	11	1	8	8	0	12	3	11	8
Percentage	17	79.4	0	0	20.6	17.6	32.3	2.9	23.5	23.5	0	35.3	8.8	32.3	23.5

"Code numbers and letters are explained in the text. A sample reading of the table is this: of the 21 people crossing "t" in lower half, 12 made "t" shorter than "h" (57.1%); none made a tented "t"; and 12 made a single-stroke "t" (57.1%)."

TABLE 6—Characteristic 5: baseline of the "h" for a total of 200 samples.*

	Samples		2a	2b	2c	2d	2e	3a	3b	3c
Incidence of baseline slanting upwards (5a)										
Number	75	23	22		3	13	14	13	52	10
Percentage	37.5	30.7	29.3		4	17.3	18.7	17.3	69.3	13.3
Incidence of baseline slanting downwards (5b)										
Number	22	4	7		2	5	4	3	15	4
Percentage	11	18.2	31.8		9.1	22.7	18.2	13.6	68.2	18.2
Incidence of even baseline (5c)										
Number	21	6	8		0	4	3	8	12	1
Percentage	10.5	28.6	38.1		0	19	14.3	38.1	57.1	4.8
Incidence of no fixed pattern (5d)										
Number	82	22	27		0	12	21	12	53	17
Percentage	41	26.8	32.9		0	14.6	25.6	14.6	64.6	20.7

*Code numbers and letters are explained in the text. A sample reading of the table is this: of the 22 people making baseline slanting downwards, 15 made a pointed arch of the "h" (68.2%).

TABLE 7—Characteristic 6: shape of the "l" for a total of 200 samples.*

	Samples	1a	1b	1c	1d	2a	2b	2c	2d	2e	3a	3b	3c	4a	4b	4c	4d
Incidence of tented "l" (6a)																	
Number	3	3	0	0	0	0	1	0	2	0	0	3	0	3	0	0	0
Percentage	1.5	100	0	0	0	0	33.3	0	66.6	0	0	100	0	100	0	0	0
Incidence of single-stroke "l" (6b)																	
Number	64	44	2	6	12	18	19	0	15	12	14	42	8	40	12	0	12
Percentage	32	68.7	3.1	9.4	18.7	28.1	29.6	0	23.4	18.7	21.8	65.6	12.5	62.5	18.7	0	18.7
Incidence of looped "l" (6c)																	
Number	28	20	1	1	6	6	11	0	4	7	3	20	5	22	3	0	3
Percentage	14	71.4	3.6	3.6	21.4	21.4	39.2	0	14.2	25	10.7	71.4	17.9	78.6	10.7	0	10.7
Incidence of closed "l" (6d)																	
Number	63	55	0	2	6	20	20	5	6	12	13	40	10	47	4	1	11
Percentage	31.5	87.3	0	3.2	9.5	31.7	31.7	7.9	9.5	19	20.6	63.5	15.9	74.6	6.3	1.6	17.5
Incidence of mixture (6e)																	
Number	42	34	0	2	6	11	13	0	7	11	6	27	9	31	2	1	8
Percentage	21	80.9	0	4.8	14.3	26.2	30.9	0	16.7	26.2	14.3	64.3	21.4	73.8	4.8	2.4	19

*Code numbers and letters are explained in the text. A sample reading of the table is this: of the 63 people making closed "l," 55 made "l" shorter than "h" (87.3%); 20 made retraced "h" loop (31.7%); 47 crossed "l" in upper half (74.6%); and 40 made pointed "h" arch (63.5%). Of the 3 people making tented "l," 3 made "l" shorter than "h" (100%).

Information contained in the raw data figures is intended to be self-explanatory. Frequency values of form occurrence are readily discerned. Numerical and percentage values for correlations between handwriting characteristics can be extracted from the six cross tabulations. Several significant correlations were noted.

1. Of the 64 individuals who exhibited the writing pattern of an initial single-stroke "t" staff (6b), 12 (18.7%) made the "t" cross in the lower half of the "t" staff. Only 10.5% of the total population made the "t" cross in this manner. This suggests that the occurrence of the single-stroke "t" staff and the occurrence of the low cross bar are not entirely independent of each other.

2. Of the 63 individuals making a closed "t" staff (6d), 55 (87.3%) made the "t" shorter than the "h." Of the total population, 156 (78%) made the "t" shorter than the "h."

3. Of the 43 individuals who did not make the "t" shorter than the "h" (combination of 1b, 1c, and 1d), 12 (44.2%) made the "h" with a retraced staff (2a). Only 27.5% of the total population made such an "h" staff. Again, the correlation appears to be significant.

4. Of the 43 individuals in Section 3, 7 (16.3%) made an "h" staff with the right side curved and the left side straight (2b), as did 32% of the general population. The fact that a lenticular, convex on the right, "h" staff is only about half as frequent in combination with the tall "t" staff as in the general population would appear to suggest a significant negative correlation.

5. Of the 21 individuals who crossed the "t" in the lower half of the "t" staff (4b), 12 (57.1%) made the "t" shorter than the "h." In the total population, 78% made the "t" shorter. Twelve (57.1%) made a single-stroke "t," as opposed to 32% of the total population. Only 4 (19%) made a closed "t," and 2 (9.5%) made a mixture of "t" shapes. In the total population, these percentages were 31.5% and 21%, respectively. These figures appear to indicate that writers who crossed the "t" in the lower half also had a tendency to vary from the Palmer copybook form [1] in other letter shapes.

6. Of the 55 individuals who made a retraced upper staff of the letter "h" (2a), 41 (74.5%) made a pointed arch on the "h." Only 66% of the total population made a pointed arch.

7. Of the 64 individuals who made the "h" staff with a curved right side and straight left (2b), 17 (26.6%) rounded the arch of the "h," and only 5 (7.8%) showed no set pattern in the formation of the "h" arch. The percentages of the total population writing with this pattern were 18% and 16%, respectively. This factor seems to indicate that adherence to copybook style in "h" staff formation is often accompanied by similar adherence in other formations of the letter.

8. Of the 42 individuals who had no set pattern in writing the loop of the "h" (2e), 16 (38.1%) had no set pattern in making the arch of the "h," and 21 (50%) showed no set pattern in constructing the baseline of the letter "h." The percentages in the total population were 16% and 41%, respectively.

9. Of the 36 individuals who made the "h" with a rounded arch (3a), 17 (47.2%) made the upper loop of the "h" curved on the right side and straight on the left, while 8 (22.2%) made the baseline of the "h" even. The percentages of the total population with these writing patterns were 32% and 10.5%, respectively. This factor appears to indicate that those individuals conforming to copybook standards in the formation of the arch of the "h" also did so in the formation of the upper loop and baseline of the "h."

10. Of the 32 individuals who had no fixed pattern in the formation of the arch of the "h" (3c), 16 (50%) had no fixed pattern in the formation of the loop of the "h." Only one individual (3.1%) made the "h" baseline even, and 17 (53.1%) had no set

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pattern in the formation of the "h" baseline. Total population percentages were 21%, 10.5%, and 41%, respectively.

11. Of the 21 individuals making the baseline of the "h" even (5c), only one (4.8%) had no fixed pattern for constructing the arch of the "h." Eight individuals (38.1%) made a rounded arch in the formation of the letter "h." Percentages in the total population were 16% and 18%, respectively.

Also of significance were certain extended correlations.

1. The Palmer copybook standard for the initial "th" combination was approximated as 1a, 2b, 3a, 4a, 5c, and 6d. Only two individuals (1%) had a writing pattern which conformed identically to this configuration. A caveat should be entered at this juncture because each characteristic in the survey contained a category labeled "no set pattern." For this reason, the 1% figure is not as definitive as might be expected. It is evident that those letter forms considered to be copybook styles were not extremely frequent in most categories. Percentages for such copybook standards were as follows: 78% made the "t" shorter than the "h"; 32% made the loop of the "h" with a curved right side and a straight left side; 18% made the arch of the "h" rounded; 71.5% crossed the "t" in the upper half of the staff; 10.5% made the baseline of the "h" even; and 31.5% made a closed "t" staff.

2. A possible correlation between the formation of a closed (retraced) "t" (6d), retraced staff of the "h" (2a), and pointed arch of the "h" (3b) was considered because of similarities in angularity of shape. Fifteen people of the total population made such a formation; however, 75% of the individuals who made the closed "t" and retraced "h" staff also made an "h" with a pointed arch.

3. A possible correlation between the formation of a single-stroke "t" (6b), the "t" taller than the "h" (1c), and the "t" cross in the upper half of the "t" staff (4a) was also investigated. Six individuals who made a single-stroke "t" also made the "t" taller than the "h." Of that six, five (83.3%) also made the "t" cross in the upper half of the "t" staff.

This survey is admittedly modest because of the size of the total population studied (200 individual writers). When only limited numbers of writers of the 200 within the sample indicated a certain condition, definitive conclusions would be precarious. This study was undertaken as an attempt to consider the possibilities for a standardized statistical approach to handwriting identification problems.

If the survey is used as it was intended, to provide percentage and numerical values for certain handwriting characteristics and characteristic combinations as well as to detail correlations, it is beneficial. It certainly reveals that more extensive research of this nature would be merited. It is believed that research of this type would greatly aid the questioned document examiner's judgment in the future.

Reference

[1] Palmer, A. N., *The Palmer Method of Handwriting*, A. N. Palmer Co., Cedar Rapids, Iowa and New York, 1900.

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