Forensic Science International, 48 (1990) 71–77
Elsevier Scientific Publishers Ireland Ltd.

ATTEMPTED DETERMINATION OF AUTHORSHIP BY BALL PEN LINE CHARACTERISTICS

A.H. LYTER III[a]*, J.J. HARRIS[b] and B.R. GREENWOOD[c]

[a]*Federal Forensic Associates, Inc. P.O. Box 31567, Raleigh, NC27612-1567 (U.S.A.),* [b]*Harris and Harris Questioned Document Examiners, 261 S. Figueroa Street, Los Angeles, CA 90012 (U.S.A.) and* [c]*Los Angeles Police, 150 N. Los Angeles Street, Los Angeles, CA90012 (U.S.A.)*

(Received April 5th, 1990)
(Revision received June 16th, 1990)
(Accepted July 9th, 1990)

Summary

The correlation between line characteristics and physical positioning of the pen is evaluated with the goal of determining the author of the writing. Line characteristics such as density, width and the presence of the anomalies, such as splitting and blobbing were noted and measured relative to writing angle and point load. Results suggest that the extreme variation which exists between writing instruments will prevent use of these techniques to determine authorship.

Key words: Questioned documents; Ball point pen; Line characteristics

Introduction

The ball point pen [1] is encountered on a daily basis by those involved in the area of questioned document examination. Since the instrument is manufactured with tolerances on the order of 0.001 inches [2], variations in performance are to be expected. Are these variations manifested in the written line in the form of measureable observations? Does the author control the appearance of these manifestations? If this is in fact the case then a determination of authorship may be possible through a systematic measurement of various characteristics of the written line.

Experimental

It was hypothesized that six factors effect the written line. The pen-mechanism and ink, writing speed [1], point load [1], writing angle [1], writing direction and writing surface. All but the first are controlled by the writer.

*To whom all correspondence and reprint requests should be addressed.

0379-0738/90/$03.50

These factors manifest themselves in three basic ways. Line width, line density and anomalies such as gooping, splitting, dotting, skipping, directional skipping, starving, splitting and blobbing [1]. It was decided to determine how three of the first six factors, pen, writing angle and point load, affected the width, line density and presence and frequency of the anomalies splitting and blobbing.

The experiment consisted of writing with 20 different ball point pens using an Anja W-10 Model B writing machine that is used by pen manufacturers to test production runs. These pens consisted of both new and previously used pens of both medium and fine point construction [2]. The Anja W-10 produced an overlapping figure eight pattern and has adjustments for writing speed, writing angle and point load by the operator.

The writing surface (paper) was the same for all tests as a requirement of the machine; and the writing speed was kept constant at 10 writing feet/min. Each of the 20 pens was allowed to write for approximately 5 min at three selected angles — 45°, 60° and 70° as measured from the writing surface. Ten pens were also varied as to point load. Table 1 indicates the angle and the point load used in both static and varying conditions.

The line width was measured with a calibrated eyepiece to the nearest 0.05 mm using ten samples from each pen to determine the average and range. The presence of anomalies was noted and a subjective quantitation was made of each type. A relationship between each anomaly and the affecting factors was noted. The line density was measured on several samples by cutting out 1-mm lengths of the written line and determining the absorption characteristics at 580 nm using a Schmadzu CS-920 TLC Scanner.

Results

The presence of the anomalies blobbing and splitting was observed and the results are listed in Table 2. The notation '0' refers to the absence of any particular anomaly and the subjective scale of 1 to 3 is used to indicate relative frequency. Only pens 1 and 3 to 9 are illustrated in Table 2. The results of the line width measurements are noted in Table 3 with only pens 1 and 3

TABLE 1

POINT LOADS AND ANGLES USED FOR MEASUREMENTS

Pen number	*Angle*	*Point load*
1–10	45°	42.8, 102.9, 163.0
1–10	60°	52.4, 128.9, 204.0
1–10	70°	56.8, 131.9, 216.4
11–20	45°	102.9
11–20	60°	128.9
11–20	70°	131.9

through 9 illustrated. Line density measurements are noted in Table 4 with the numerical values being the integrated peak area. Due to the failure of pens 1 and 3 to provide useful data regarding density to authorship, further measurements were not made.

Analysis

The results presented in Table 2 indicate that both writing angle and

TABLE 2

FOR ACTUAL FREQUENCY OF ANOMALIES CORRELATED TO POINT LOAD AND WRITING ANGLE SEE TABLE 1

Pen No.	*Point load (g)*	*Splitting*			*Blobbing*		
		45° (pen angle)	*60°*	*70°*	*45° (pen angle)*	*60°*	*70°*
1	50*	1	1	0	1	0	0
1	135	2	1	0	2	0	0
1	220	2	1	0	2	0	0
3	50	0	0	0	2	2	1
3	135	0	0	0	3	3	2
3	220	1	0	0	3	3	3
4	50	1	3	3	0	0	0
4	135	2	3	3	0	0	0
4	220	3	3	3	1	0	0
5	50	0	0	0	0	0	0
5	135	1	0	0	1	0	0
5	220	1	0	0	2	0	0
6	50	1	0	0	2	0	0
6	135	1	1	0	2	0	0
6	220	1	1	1	3	0	0
7	50	2	1	0	0	0	0
7	135	3	2	0	0	0	0
7	220	3	2	1	1	0	0
8	50	2	1	0	1	0	0
8	135	2	2	0	2	0	0
8	220	2	2	1	2	0	0
9	50	0	0	0	1	0	0
9	135	1	0	0	2	0	0
9	220	1	0	0	2	0	0

* = Approximate; 0 = none; 1 = slight; 2 = moderate; 3 = frequent.

point load affect the presence and freqeuncy of anomalies to the written line. There appears, however, an overriding indication that under normal writing conditions, angle and point load, the instrument used dictates the presence of such anomalies.

At 45° ink smears began to appear for a majority of the pens and they increased with the point load, indicating that the pen housing was rubbing on the paper. Pens that functioned properly at 45° were of the medium point size and one defective pen smeared ink at every angle and point load setting. Therefore, while ink smears may suggest a low pen angle, the pen in ques-

TABLE 3

MEASUREMENT OF LINE WIDTHS IN MILLIMETERS AS A FUNCTION OF POINT LOAD AND WRITING ANGLE

Pen No.	*Point load (g)*	*Average line width*			*Range of line widths*		
		45° (pen angle)	*60°*	*70°*	*45° (pen angle)*	*60°*	*70°*
1	50*	0.20	0.21	0.22	0.2–0.25	0.2–0.3	0.2–0.3
1	135	0.28	0.31	0.32	0.2–0.3	0.25–0.4	0.25–0.35
1	220	0.33	0.36	0.33	0.3–0.4	0.3–0.4	0.25–0.4
3	50	0.21	0.23	0.22	0.2–0.25	0.2–0.4	0.2–0.25
3	135	0.30	0.31	0.32	0.25–0.35	0.25–0.4	0.3–0.35
3	220	0.32	0.34	0.34	0.3–0.35	0.3–0.4	0.3–0.4
4	50	0.20	0.22	0.24	0.15–0.25	0.15–0.3	0.15–0.3
4	135	0.28	0.29	0.30	0.2–0.3	0.2–0.4	0.2–0.35
4	220	0.34	0.33	0.30	0.25–0.5	0.25–0.4	0.2–0.4
5	50	0.20	0.21	0.20	0.2	0.2–0.25	0.15–0.25
5	135	0.26	0.29	0.29	0.2–0.3	0.25–0.35	0.2–0.4
5	220	0.29	0.29	0.31	0.25–0.3	0.25–0.35	0.3–0.35
6	50	0.20	0.22	0.20	0.15–0.25	0.2–0.3	0.2–0.25
6	135	0.22	0.26	0.28	0.2–0.25	0.2–0.3	0.2–0.4
6	220	0.25	0.29	0.31	0.2–0.3	0.25–0.35	0.3–0.35
7	50	0.21	0.20	0.23	0.15–0.25	0.15–0.25	0.2–0.3
7	135	0.26	0.30	0.29	0.2–0.3	0.25–0.35	0.25–0.3
7	220	0.29	0.30	0.33	0.2–0.4	0.3–0.4	0.3–0.4
8	50	0.22	0.26	0.26	0.2–0.25	0.2–0.3	0.2–0.3
8	135	0.26	0.29	0.30	0.2–0.3	0.25–0.4	0.25–0.35
8	220	0.29	0.35	0.36	0.25–0.4	0.3–0.4	0.3–0.4
9	50	0.24	0.24	0.26	0.2–0.3	0.2–0.3	0.2–0.3
9	135	0.26	0.32	0.28	0.2–0.3	0.3–0.4	0.25–0.35
9	220	0.31	0.33	0.32	0.3–0.35	0.3–0.35	0.3–0.4

TABLE 4

MEASUREMENT OF LINE DENSITY AS A FUNCTION OF POINT LOAD AND WRITING ANGLE

Pen no.	*Point load (g)*	*Writing angle (degrees)*	*Average line density*	*Range of line density*
1	42.8	45	60.4	32–98
1	102.9	45	100.3	34–184
1	163.0	45	124.4	54–259
1	52.4	60	83.7	33–119
1	128.9	60	102.9	46–175
1	204.0	60	118.5	50–235
1	56.8	70	116	35–318
1	131.9	70	87.2	44–200
1	216.4	70	109.2	44–173
3	42.8	45	158.2	67–333
3	102.9	45	92.5	34–143
3	163.0	45	124.2	53–242
3	52.4	60	143.3	43–469
3	128.9	60	126.9	76–186
3	204.0	60	196	91–346
3	56.8	70	80.5	36–153
3	131.9	70	77.9	45–136
3	216.4	70	144.9	78–219

tion would have to be tested to determine its critical writing angle and for that matter, whether it was defective at any angle.

The line width measurements (Table 3) suggest several conclusions. Neither the average line width nor the range of line widths is significant enough in consistency or differentiating qualities to be a helpful measurement. It is only possible to determine fine point instruments from medium point instruments at the lowest measured angle. Note that pens 5 and 6, which are both fine point, at 45° and an increased point load do not have the range of values of the other instruments. Even this measurement is dependent on point load in combination with writing angle and thus difficult to control.

The measurement of line density appears to have no value due to the large range occurring within each measurement. No consistency occurs relating density to either point load or writing angle. It would appear that this measurement is highly dependent upon the writing instrument used and cannot be individualized for the purposes of identifying a particular writer.

Conclusions

The characteristics appearing in the written line and measurable by the techniques described above appear to be attributable to both the writing instrument and the writer. This combination of factors is inseparable and therefore the identification value of such ink line comparisons if any, requires that all writing examined be produced with the same instrument and under precisely the same conditions, i.e. point load, writing angle and paper type.

Acknowledgements

The authors wish to thank Papermate Pen Company of Santa Monica, California for their assistance in producing the controlled writing and especially Mr. William Naggar, Senior Quality Engineer for his contributions.

Addendum A

Ball point pen

A handwriting instrument complete with all of the auxiliary components, such as barrels, caps, clips, etc., required to make it suitable for usage as desired by its purchaser and having as its distinguishing feature or characteristic a writing tip containing a rotatable ball for contacting the writing surface for the purpose of depositing the writing fluid on the writing surface.

Point load

The vertical component of the force applied to the writing tip during line generation.

Writing angle

The included angle measured from the plane of the writing surface to the longitudinal axis of the pen when in a writing position.

Blobbing

The accumulating of ink on the exterior of the point assembly, with the ink so accumulated dropping intermittently to the surface being written upon.

Dotting

The deposit of small amounts of extraneous ink on the paper, occurring with predictable regularity under given conditions.

Skip

The self-recoverable, temporary interruption (no deposition of ink) in an otherwise continuous line.

Directional skipping

That skip which may occur after an abrupt (90° or more) change in the direction of line generation.

Starving

A condition in which there is an inadequate flow of writing fluid to the writing surface.

Splitting

Division of a line into two or more or less equal portions by a non-inked area running generally parallel to the direction of line generation.

Gooping

The accumulating of ink on the exterior of the point assembly as a result of writing, with the bulk of the ink so accumulating continuing to adhere to the point.

Addendum B

Ball

Stainless steel or tungsten carbide

medium — 1 mm (0.039″)	protrusion —	(0.28 to 0.33 mm) (0.011 — 0.013″)
fine — 0.7 mm (0.027″)		(0.21 to 0.26 mm) (0.008 — 0.010″)

References

1 Nomenclature and Test Parameters for Ball Point Pens, Writing Instrument Manufacturers Association, Inc., 1625 I Street N.W., Washington, DC 20006 (202) 331-1429 (selected excerpts attached as Addendum A).

2 Dr. P.M. Daugherty, Anja Engineering Corp. Monrovia, CA Telephonic Communications (appropriate information attached as Addendum B).