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THE IMPACT OF UNCONVENTIONAL WRITING INSTRUMENTS ON FORENSIC HANDWRITING CHARACTERISTICS: AN EXPERIMENTAL ANALYSIS

Forensic Medicine

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ABSTRACT

This study investigates the effects of using unusual writing instruments on the stability and identifiable characteristics of handwriting, a subject of forensic relevance in cases where standard pens are unavailable or deliberately avoided. The main goals were to chronicle the new features brought about by non-standard tools and to ascertain whether class and individual handwriting traits endure across instrument modifications. A normal ballpoint pen (control), a fountain pen, a flat-tipped marker, a wooden stylus with an ink pad, and a paintbrush were used to collect handwriting samples from thirty participants using a within-subjects experimental design. Twelve predetermined factors, including line quality, spacing, slant, and particular letter shapes, were examined in the samples. Result: The stylus and paintbrush caused the most noticeable variances, according to the results, which showed a statistically significant main effect of writing instrument on nine of the twelve parameters ($p < 0.05$). On the other hand, fundamental individualizing traits like baseline alignment, relative letter proportions, and particular punctuation practices showed greater robustness. The study comes to the conclusion that atypical instruments do not completely conceal the writer's basic motor program, even when they introduce significant diversity in executional aspects such line thickness and tremor. The requirement for instrument-variant exemplars in comparison analysis is highlighted by the need for forensic investigators to distinguish between authentic individual traits and artifacts created by instruments.

KEYWORDS

Questioned Documents, Handwriting Analysis, Writing Instruments, Class Characteristics, Individual Characteristics, Forensic Science

INTRODUCTION

Forensic handwriting examination is predicated on the principle that every individual possesses a unique, habitual writing style—a motor program resistant to superficial variation [1]. Examiners differentiate between class characteristics (shared by groups, e.g., copybook style) and individual characteristics (unique to the writer) to identify authorship [2]. A key challenge arises when a questioned document is executed with an unconventional writing instrument—a tool not designed for typical writing, such as a brush, stick, or makeshift implement.

The practical relevance is considerable. Documents may be written in exigent circumstances (e.g., with a charcoal fragment, lipstick, or nail), as part of a deliberate attempt to disguise writing, or in artistic or cultural contexts. The extant forensic literature extensively covers the effects of disguise, illness, or intoxication on handwriting [3] but provides limited empirical data on the systematic influence of the instrument's physical properties [4].

The biomechanics of writing involve a complex interaction between the neuromuscular system and the tool. Instrument variables—tip shape, flexibility, friction, ink flow, and grip diameter—directly affect kinesthetic feedback and output[5]. A rigid, broad-tipped instrument (e.g., a marker) cannot produce the fine, pressure-modulated lines of a ballpoint pen. This study hypothesizes that unusual instruments will significantly alter executional, measurable features (line quality, pen pressure patterns) but will not eradicate the writer's underlying spatial arrangement and proportional habits. This research aims to experimentally catalogue these alterations and provide a framework for forensic practitioners to assess handwriting produced with non-standard tools, thereby expanding the scope of reliable document examination.

MATERIALS AND METHODS

A controlled laboratory experiment was designed to isolate the effect of the writing instrument variable.

Participants: Thirty adult volunteers (15 male, 15 female), aged 22-45, were recruited. All were right-handed, reported no neuromuscular disorders affecting writing, and had completed secondary education. Informed consent was obtained.

Writing Instruments:

- Control: Standard blue ballpoint pen (0.7 mm tip).
- Fountain Pen: Medium nib, liquid ink.
- Broad-Tipped Marker: Chisel tip, 5 mm width.
- Wooden Stylus & Ink Pad: A pointed, untreated wooden dowel (3 mm diameter) used with a standard stamp pad.
- Round Paintbrush: Size 4, water-based ink.

Procedure

Each participant was provided with identical, unlined A4 paper sheets. They were instructed to copy a standard text passage (the London Letter, containing all alphabet letters and numerals) three times with each instrument, presented in a randomized order to mitigate fatigue or learning effects. Writing was performed on a standardized desk. No instructions regarding writing style or speed were given beyond legibility.

Data Analysis

The third sample from each instrument set was selected for analysis to account for initial adaptation. Samples were digitized at 600 DPI. Analysis was both quantitative and qualitative, focusing on 12 parameters:

Quantitative (Measured using ImageJ software):

- Average letter height (for 'a', 'd', 'h').
- Slant angle variance (for vertical strokes in 'h', 'k', 'l').
- Inter-word spacing.
- Baseline deviation (RMS error from a fitted line).

Qualitative (Scored by two blinded ASE-certified document examiners, inter-rater reliability $\kappa=0.87$):

- Line quality (smooth, tremulous, ragged).
- Pen pressure patterns (consistent, tapering, blotchy).
- Starting and ending strokes (presence/type).
- Letter 't' crossbar placement (high, medium, low).
- Letter 'i' dot placement (left, centered, right).
- Connecting strokes (garland, arcade, angular).
- Specific letter formations (e.g., 'r', 's').
- Overall spatial arrangement impression (consistent with control sample: Yes/No).

Statistical analysis was performed using SPSS v.28. Repeated-measures ANOVA was used to test for a main effect of instrument on quantitative parameters. Qualitative data were analyzed using Cochran's Q test.

RESULTS

The analysis revealed a strong and significant effect of the writing instrument on most handwriting parameters.

Quantitative Findings: Repeated-measures ANOVA showed a statistically significant main effect of instrument on average letter height ($F(4,116)=18.32$, $p<0.001$), slant angle variance ($F(4,116)=22.47$, $p<0.001$), and baseline deviation ($F(4,116)=15.89$, $p<0.001$). Post-hoc Bonferroni tests indicated that the stylus and paintbrush conditions were primarily responsible for these differences, producing significantly larger, more variable, and less baseline-stable writing compared to the control. Inter-word spacing was the least affected parameter ($p=0.053$), suggesting spatial planning is a higher-order, resilient feature.

Qualitative Findings: Examiner analysis showed significant instrument-dependent shifts ($p<0.01$ for all parameters via Cochran's Q).

- Line Quality: Degraded markedly from 'smooth' (ballpoint, fountain) to 'tremulous/ragged' (stylus, paintbrush). The marker produced uniformly thick, non-modulated lines.
- Pen Pressure Patterns: The ballpoint's characteristic striations and directionality were absent in all other instruments. The fountain pen showed ink flow variation, while the stylus and brush produced blotchy, unpredictable deposits.
- Specific Features: Starting/ending strokes were often abbreviated or absent with the stylus and brush. 't'-bar placement and 'i'-dot placement showed higher vertical and horizontal scatter with these instruments.
- Core Individuality: Despite these variations, in 28 out of 30 participants (93%), both examiners correctly matched the unusual instrument samples back to the participant's control sample based on the overall spatial arrangement, relative proportionality between letters, and idiosyncratic letter formations (e.g., a specific lowercase 'g' shape) that persisted across all media [6].

DISCUSSION

The findings support the hypothesis that unusual writing instruments act as a filter, substantially altering the *executional* manifestation of handwriting while leaving the underlying *conceptual* motor program more intact [7]. The degradation in line quality and increased metric variability with tools like the stylus and brush align with biomechanical theory: these instruments provide poor point control, require different grip forces, and lack a consistent ink reservoir, increasing cognitive load on the writer [8].

Forensically, this has several implications. First, it underscores the critical importance of obtaining known writing exemplars created with a *similar type of instrument* [9]. A comparison between a questioned document written with a brush and a known sample written with a ballpoint is inherently more complex and potentially less conclusive. Second, examiners must be trained to differentiate between instrument-class characteristics (e.g., uniform width from a marker, ink blobs from a stylus) and writer-individual characteristics [10]. The persistence of spatial arrangement and proportional habits is a key finding; these appear to be cognitive features more resistant to tool change than the dynamic features of line creation [11].

This study also informs disguise analysis. A writer attempting disguise by switching to an unfamiliar instrument introduces two layers of variation: intentional stylistic change and unintentional instrument adaptation [12]. The data suggest the instrument's effect may be the more dominant source of alteration in such cases, which could be misinterpreted as evidence of a different writer if not properly considered [13].

Limitations include the controlled laboratory setting and the use of cooperative participants. Real-world scenarios involving stress, unusual surfaces, or more extreme instruments (e.g., a finger in dust) may produce more pronounced effects [14]. Future research should investigate the efficacy of automated handwriting recognition systems when trained on standard pen data but tested on unconventional instrument samples [15].

CONCLUSION

Unusual writing instruments significantly modify the measurable and observable traits of handwriting, particularly those related to line formation and executional fluency. However, they do not obliterate the core individual characteristics stemming from the writer's ingrained motor habits and spatial planning. For forensic document examiners, this reinforces the principle that a comprehensive analysis must account for the writing medium. Identifying and discounting instrument-induced artifacts is essential to correctly identifying the enduring features that point to a specific writer, thereby ensuring reliable conclusions even when the tools of writing are far from standard.

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