IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

FAMILIAL RESEMBLANCE AND INHERITANCE IN HANDWRITING AMONG BIOLOGICAL SISTERS: A FORENSIC PERSPECTIVE

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Abstract : Handwriting serves as a distinctive behavioural expression shaped by both biological inheritance and environmental learning. This study investigates the hereditary component of handwriting by analyzing familial resemblance in specific handwriting features among biological sisters. A total of seventy handwriting samples were collected from thirty-five pairs of sisters to assess the extent of resemblance and individuality across selected handwriting traits.

The research focused on seven major handwriting parameters: slant, baseline alignment, size of writing, spacing, crossbar of 't', loops, and overall style. Each trait was examined comparatively to identify similarities that may indicate genetic influence. The study revealed that traits such as slant, baseline alignment, and loops exhibited notable resemblance among sister pairs, suggesting hereditary and neuromuscular connections. However, differences in spacing, size, and style were also observed, reflecting the presence of individuality even within familial lines.

These findings confirm that handwriting traits can be partially inherited but remain distinctly individual due to unique motor patterns and cognitive development. From a forensic perspective, recognizing hereditary resemblance is essential to prevent misidentification in cases involving related individuals. The study thus emphasizes the importance of understanding genetic contributions in handwriting analysis to enhance the reliability of forensic document examination.

Keywords: Handwriting, Individuality, Familial resemblance, Siblings, Forensic document examination.

I. INTRODUCTION

Handwriting is a complex psychomotor activity that reflects the coordination between the brain, muscles and visual perception. It represents a unique combination of learned behaviour and inherited motor patterns, making it an important feature for personal identification in forensic science [1]. The act of writing is governed by neurological processes that regulate fine motor control, rhythm and muscle movement, all of which are influenced by both genetic and environmental factors [3,4]. Over time, as these motor patterns become habitual, handwriting develops into a stable and individualized form of expression.

In forensic document examination, handwriting analysis is a fundamental technique used to determine the authorship of questioned documents. Every individual develops specific writing habits such as the angle of slant, pressure pattern or formation of loops that will contribute to the individuality of handwriting [6,7]. Despite these distinctive features, it is possible to observe similarities in handwriting among family members, particularly siblings, due to shared hereditary and neuromuscular characteristics [14,15]. Familial resemblance in handwriting becomes a crucial consideration in forensic identification, as close relatives may display overlapping traits that could complicate authorship determination.

Several studies have explored the hereditary aspect of handwriting by examining family members and twins. Saini, Srinivasan and Kapoor [15] demonstrated that specific features such as baseline alignment and letter slant tend to be similar among related individuals, suggesting a genetic contribution to motor control patterns. Similarly, Saran et al. [16] found that handwriting slant showed strong resemblance within family groups, supporting the hypothesis of familial inheritance. Ahuja et al. [14] also reported that monozygotic twins exhibited closer similarities in handwriting than dizygotic twins, confirming a hereditary link. These findings collectively indicate that certain handwriting features, especially those dependent on neuromuscular coordination, may be transmitted genetically across generations. While genetic factors play a role in shaping handwriting, individual learning and environmental influences still contribute significantly to handwriting variation. However, when comparing closely with related individuals, such as biological sisters, the inherited components of writing patterns become more apparent [15]. Shared physiological traits such as muscle tone, hand structure and motor reflexes can lead to similar stroke patterns and writing rhythm. This resemblance

provides an opportunity to study how inherited neuromotor mechanisms manifest in handwriting, while still maintaining the individuality in stylistic and spatial features.

The study of familial resemblance in handwriting has practical implications in forensic document examination. In cases where family members are involved, examiners must recognize that certain handwriting features may appear similar due to shared heredity rather than deliberate imitation [10,25]. Awareness of hereditary resemblance helps forensic experts avoid misinterpretation and strengthens the reliability of authorship conclusions. Moreover, understanding inheritance patterns in handwriting supports the broader forensic principle that individuality persists despite of the genetic similarities [26,28].

Therefore, the present study aims to investigate the extent of familial resemblance and inheritance in handwriting among biological sisters. By analyzing selected handwriting characteristics such as slant, baseline alignment, loops and crossbar of 't', this research seeks to determine which traits show strong hereditary influence and which will still remain uniquely individual. The results are expected to contribute to the forensic understanding of handwriting individuality within family groups and enhance the accuracy of handwriting based identification.

METHODOLOGY:

The study adopted a comparative research design to explore hereditary influence and familial resemblance in handwriting among biological sisters. A total of seventy handwriting samples were collected from thirty-five pairs of biological sisters from diverse backgrounds. Purposive sampling was used to ensure that each pair consisted of verified biological sisters without any neurological or physical conditions which affects the handwriting. Focusing on female participants helped to control gender-based variations in fine motor coordination [27].

Each participant was asked to write a standard English paragraph on unruled A4 white paper using a blue ballpoint pen under uniform conditions. Samples were collected in a comfortable, distraction-free setting to ensure natural handwriting flow. The collected samples were analysed using seven standard handwriting parameters: slant, baseline alignment, size, spacing, crossbar of 't', loops and overall style. For this paper, emphasis was placed on slant, baseline alignment, loops and crossbar of 't', as these traits are most influenced by neuromuscular coordination and hereditary factors [14,15].

The analysis followed the **ACE-V Process**-Analysis, Comparison, Evaluation and Verification, to ensure systematic examination of the handwriting [10,25]. Each handwriting trait was observed and compared between elder and younger sister and the degree of resemblance was **quantified in percentage values** based on the frequency of similar features across the sample pairs. Magnifiers and measurement scales were used to ensure precision and the data were organized in comparative tables to illustrate the proportion of resemblance for each handwriting parameter.

Ethical approval and informed consent were obtained from all participants. The methodology ensured unbiased evaluation of handwriting features to identify traits showing familial resemblance and genetic inheritance while maintaining confidentiality and scientific accuracy.

RESULT AND ANALYSIS:

The comparative analysis of handwriting traits among biological sisters was carried out to determine the degree of resemblance and the possible hereditary transmission of handwriting features. The selected handwriting parameters were slant, baseline alignment, crossbar of 't' and loop and these were evaluated using the ACE-V forensic framework. The results revealed that some traits displayed a strong degree of similarity among sisters, indicating that there is a possible genetic influence, while others showed moderate resemblance which reflects that the combined role of heredity and environment.

Table 1: Comparative Analysis of Slant Trait in the Handwriting of Biological Sisters

Sister		Slant				Total
		RIGHT	LEFT	STRAIGHT	COMBINATION	
Elder	Count	08	15	10	02	35
	%	22.85%	42.85%	28.57%	5.71%	50.00%
Younger	Count	11	12	07	05	35
	%	31.42%	34.28%	20%	14.28%	50.00%
Total		19 (27.14%)	27 (38.57%)	17 (24.28%)	07 (10%)	70 (100%)

Table 1 represents the comparison of handwriting slant among elder and younger sisters across collected samples. The analysis was carried out to identify whether the direction of handwriting slant showed similarities or variations among siblings. Four categories of slant were considered in this study: right slant, left slant, straight slant, and combination. Out of the total 70 handwriting samples, the distribution was calculated for both elder and younger sisters individually, and then compared with the overall totals.

Among the elder sisters, left slant was the most common with 42.85% of samples, followed by straight slant with 28.57%. Right slant was found in 22.85% of cases, while combination slant was the least observed with only 5.71%. This indicates that elder sisters predominantly exhibited a leftward inclination in handwriting, showing a tendency toward more reserved or inward-oriented writing patterns. In the case of younger sisters, the distribution was slightly different. The left slant accounted for 34.28%, while right slant was nearly similar at 31.42%. Straight slant was observed in 20% of the cases, and combination slant was comparatively higher in younger sisters 14.28% than elder sisters. This shows that younger sisters demonstrated a more balanced distribution of slant styles, with a significant presence of both right and left slants along with more instances of mixed patterns. When comparing the overall results of both elder and younger sisters, left slant was found to be the dominant type 38.57%, followed by right slant 27.14%, straight slant 24.28%, and combination slant 10%. This overall distribution highlights that although left slant is the most frequent among both groups, younger sisters showed greater diversity with righter and combination slants compared to the elder sisters who mainly leaned toward left and straight slants.

The examination of slant demonstrated a **high degree of similarity** in several sister pairs. Most of the samples exhibited comparable angular inclinations, either consistently rightward or leftward, suggesting that the slant of handwriting is influenced by **neuromuscular coordination and inherited motor rhythm**. Similar outcomes were observed in earlier studies by Saini and Kapoor (2015) [15] and Saran et al. (2013) [16], which reported that the angular pattern of handwriting often follows familial tendencies. Minor variations noted in some samples were attributed to individual writing pace and psychological states at the time of writing. Overall, the results indicate that slant represents one of the most hereditary handwriting characteristics among biological sisters.

Table 2: ***Assessment of Baseline Alignment Patterns in the Handwriting of Biological Sisters***

Sister		Baseline Alignment				Total
		Ascending	**Descending**	**Straight**	**Combination**	
Elder	**Count**	16	04	12	03	**35**
	%	45.71%	11.42%	34.28%	8.57%	**50.00%**
Younger	**Count**	10	04	13	08	**35**
	%	28.57%	11.42%	37.14%	22.85%	**50.00%**
Total		**26 (37.14%)**	**08 (11.42%)**	**25 (35.71%)**	**11 (15.71%)**	**70 (100%)**

Table 2 represents the comparison of baseline alignment in handwriting among elder and younger sisters across 70 samples. Baseline alignment reflects the direction in which handwriting moves across the line and can provide important insight into the writer's motor control, consistency, and psychological tendencies. The four categories considered in this study were ascending, descending, straight, and combination.

Among the elder sisters, ascending baseline was most commonly observed, accounting for 45.71% of the samples. This was followed by straight baseline at 34.28%, indicating that many elder sisters maintained either upward or straight alignment while writing. Descending baseline was found in 11.42% of the cases, while combination baseline was relatively rare with only 8.57%. This suggests that elder sisters predominantly exhibited a more controlled and upward-moving baseline, reflecting stable handwriting characteristics. In the case of younger sisters, the distribution was more evenly spread. Straight baseline was the most frequent at 37.14%, followed by ascending at 28.57%. Combination baselines accounted for 22.85%, which was significantly higher compared to elder sisters, showing that younger sisters tended to vary more in their writing alignment. Descending baseline was found in 11.42% of the samples, similar to elder sisters. This indicates that younger sisters displayed more diversity in their baseline alignments, with a notable presence of mixed writing styles. When considering the total distribution of baseline alignment among all 100% samples, ascending baseline was most common 37.14%, closely followed by straight baseline 35.71%. Descending baseline accounted for 11.42%, and combination alignment was observed in 15.71%. These results highlight that while ascending and straight baselines dominated overall, younger sisters showed greater variability with more frequent use of combination baselines compared to elder sisters.

Baseline alignment analysis also revealed remarkable similarity among many sister pairs. Both elder and younger siblings frequently maintained a consistent line direction that is either horizontal or slightly ascending which demonstrates that shared motor control and stability in the handwriting execution. This supports the idea that baseline alignment is strongly influenced by inherited neuromuscular control [15]. The findings are consistent with Ahuja et al. (2018) [14], who emphasized the hereditary aspect of fine motor coordination in handwriting. Slight variations observed in a few cases may be attributed to writing surface inclination or pen-handling differences.

Table 3: Comparative Study of Crossbar Formation in Letter 't' in the *Handwriting* of Biological Sisters

Sister		Cross Bar of 't'				Total
		Left	Right	Middle	Mixed	
Elder	Count	02	07	21	05	**35**
	%	5.71%	20.00%	60.00%	14.28%	**50.00%**
Younger	Count	00	06	26	03	**35**
	%	0.00%	17.14%	74.28%	8.57%	**50.00%**
Total		**02 (2.85%)**	**13 (18.57%)**	**47 (67.14%)**	**08 (11.42%)**	**70 (100%)**

Table 3 illustrates the comparison of the cross bar of the letter 't' among elder and younger sisters, categorized into left, right, middle, and mixed positions. The placement of the cross bar is a key feature in handwriting examination, reflecting writing habits, rhythm, and motor coordination.

Among elder sisters, the majority of samples 60% displayed the middle cross bar position, indicating a tendency toward uniformity and structured handwriting. Right cross bars were present in 20% of the samples, while mixed styles accounted for 14.28%. A small proportion 5.71% of elder sisters placed the cross bar toward the left, showing it as the least common variation in this group. In contrast, younger sisters showed an even stronger preference for the middle cross bar, with 74.28% of their samples falling into this category. The right cross bar was observed in 17.14% of cases, while the mixed category was limited to 8.57%. Notably, none of the younger sisters used the left cross bar, highlighting its rarity within this group. When considering the overall distribution, the middle cross bar dominated with 67.14% across both groups, followed by right cross bars at 18.57%. Mixed cross bars accounted for 11.42%, while left cross bars were the least frequent, with only 2.85%.

The evaluation of the crossbar of the letter 't' revealed **moderate resemblance** between sister pairs. In several cases, the crossbar height and stroke length were similar, indicating early-learned and possibly inherited hand movements. However, variations in pressure, position and style of execution were also noted, reflecting **individual expression within a shared familial pattern**. The findings align with Kiran and Sridhar (2017) [18], who reported that structural features such as the crossbar of 't' may show hereditary tendencies but are often personalized through writing experience and cognitive preference. This characteristic therefore represents both the inherited and individually developed traits.

Table 4: Analysis of Loop Formation in the *Handwriting* of Biological Sisters

Sister		Loops (upper & lower)				Total
		Open	Closed	Mixed/variable	No loops	
Elder	Count	07	13	14	01	**35**
	%	20%	37.14%	40.00%	2.85%	**50.00%**
Younger	Count	10	19	05	01	**35**
	%	28.57%	54.28%	14.28%	2.85%	**50.00%**
Total		**17 (24.28%)**	**32 (45.71%)**	**19 (27.14%)**	**02 (2.85%)**	**70 (100%)**

Table 4 presents the distribution of loops in handwriting, categorized into open, closed, mixed/variable, and no loops among elder and younger sisters. Loops are one of the most significant features in handwriting analysis, reflecting writing fluency, motor coordination, and stylistic preferences.

Among elder sisters, the majority of samples showed mixed or variable loops 40%, indicating flexible handwriting habits with a tendency to adapt styles depending on writing speed and context. Closed loops were also frequent, observed in 37.14% of the cases, suggesting a structured and compact writing style. Open loops were found in 20% of samples, while no loops were rare, seen in only 2.85% of elder sisters. For younger sisters, closed loops were predominant, making up 54.28% of the total, which demonstrates greater consistency and compactness in letter formation compared to their elder counterparts. Open loops were present in 28.57% of the younger sisters' samples, showing a slightly freer style. Mixed or variable loops appeared in 14.28% of cases, while no loops were again least observed at 2.85%. When looking at the overall totals, closed loops were the most common pattern 45.71%, followed by mixed/variable loops at 27.14%. Open loops accounted for 24.28%, and no loops were the least frequent at just 2.85%. The comparative analysis of loops in upper and lower zones showed **moderate to strong resemblance** among sister pairs. In many samples, similar loop curvature and dimensions were observed, particularly in the lower zone, suggesting a **shared neuromuscular pattern influenced by heredity**. These results are supported by Ahuja et al. (2018) [14] and Tobria et al. (2020) [20], who emphasized the genetic contribution to handwriting rhythm and motor structure. Differences were noted in the upper zone loops which may be attributed to individual stylistic development, which often evolves through practice and education. Overall, the loop formation displayed the combined effect of genetic inheritance and personal adaptation.

The overall analysis indicates that **handwriting traits such as slant and baseline alignment** exhibit the highest degree of familial resemblance, confirming hereditary influence. Traits like **crossbar of 't' and loops** display partial resemblance, reflecting both the genetic and environmental contributions. The results collectively demonstrate that handwriting individuality persists despite shared

hereditary patterns, aligning with the forensic principle that *no two handwriting samples, even from closely related individuals, are identical* [10,12].

DISCUSSION:

The findings of this study strongly support the hypothesis that handwriting shares certain hereditary components, as reflected in the similarities observed among biological sisters. The traits analysed-slant, baseline alignment, crossbar of 't' and loops which demonstrated varying degrees of resemblance, with slant and baseline showing the most consistent patterns. These results suggest that handwriting is influenced not only by learned behaviour but also by inherited neuromuscular coordination and physiological characteristics.

The significant similarity in slant and baseline alignment corresponds with the findings of Saini and Kapoor (2015) [15] and Saran et al. (2013) [16], who reported that handwriting rhythm and alignment are often inherited through shared genetic motor control patterns. These traits are less likely to be consciously altered by environmental factors, which explains their consistency among the sibling pairs. The moderate resemblance in the crossbar of 't' and loops further indicates that while genetic influence shapes certain movement tendencies, individual experience and practice refine these traits into personal expressions [14,18]. The study also demonstrates that handwriting individuality persists even among family members. While hereditary factors contribute to the structural and motor aspects of writing, cognitive and environmental influences introduce unique variations that make each handwriting distinct. This aligns with the forensic principle that no two handwriting samples, even from genetically related individuals, can be identical (Hicklin et al., 2022) [10]. Such understanding is crucial in forensic examinations involving related suspects or witnesses, as examiners must recognize familial similarities while focusing on unique individual traits for reliable identification.

In conclusion, the study's results partially prove the hypothesis. Certain handwriting characteristics exhibit clear hereditary resemblance, confirming that genetic and physiological factors contribute to handwriting formation. However, individuality remains dominant, as environmental exposure and personal development continue to shape the finer details of writing. The balance between inheritance and individuality underscores the scientific foundation of forensic handwriting identification, reaffirming that the handwriting is both a biological and behavioural signature which is unique to every individual.

CONCLUSION:

The present study concludes that handwriting exhibits measurable familial resemblance among the biological sisters, primarily due to shared genetic and neuromuscular factors. The comparative analysis revealed that certain handwriting traits particularly slant and baseline alignment demonstrated strong similarity within the sister pairs which indicates the presence of hereditary influence. Meanwhile, features such as the crossbar of 't' and loops showed moderate resemblance, suggesting that these traits are shaped by both the genetic inheritance and individual learning. These results affirm that handwriting can reflect hereditary tendencies, yet it continues to maintain personal uniqueness.

From a forensic perspective, the findings emphasize the importance of understanding hereditary patterns when examining the handwriting samples from related individuals. Forensic document examiners must recognize that similarities arising from familial inheritance may coexist with unique individual characteristics. Awareness of these overlapping features enhances the reliability and accuracy of handwriting identification. Ultimately, this study reinforces that while heredity contributes to certain aspects of handwriting, individuality remains dominant, making handwriting a scientifically reliable means of personal identification.

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