

"Study of changes in signature characters with serial increments of induced myopia"

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ABSTRACT

Introduction: Signature is a visuo-motor skill which requires continuous processing of the visual perceptions to execute effectively the fine hand movements. Any defect in the visual inputs could affect a change in the signature. Understanding the variation in signature characters caused by visual acuity change can help better evaluate questioned documents. In our study we try to analyze and catalogue these changes in the signature of a person.

Methodology: The study was conducted among 100 subjects above 18 yrs of age and having normal visual acuity. They were asked to provide three samples of their signature, after which the same tasks was repeated with serial increments of myopia. Changes in the signature class characters were analyzed and compared in all grades of myopia.

Results: In this study it was found that there was increase in signature size, signature space between letters and decrease in the Middle zone letter size in different grades of induced myopia. The signature slope and letter slant also changes in most subjects with change in the visual acuity. The changes were not linear and couldn't be used to predict the grade of myopia.

Conclusion: From the findings of the study it could be concluded that visual processes significantly influence the signature and myopia by effecting the visual acuity would induce corresponding changes in the signature class characters. These changes need to be kept in mind while evaluating question documents.

Key Words: visual acuity, class characters, myopia, Signature.

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INTRODUCTION

Mankind differs from other forms of life in many ways. One key skill which we have come to master is communication. From the time language was first devised for communication we have come a long way. Now is the age of digital communication. We have moved from writing to printing and from hard copies to E- copies or soft copies. Though these developments are undeniable, written documents can't be completely phased out¹.

Whenever we have a document in question, written or digital then most important questions which need to be answered are about its originality, Authenticity and source. The examination of questioned documents consists of the analysis and comparison of questioned handwriting, hand printing, typewriting, commercial printing, photocopies, papers, inks, and other documentary evidence with known material in order to establish the authenticity of the contested material as well as the detection of alterations².

Handwriting includes cursive writing, hand printing, numbers and other marks or signs. A variety of documents like checks, credit card receipts, bomb threats, anonymous letters, bank robbery notes, prescriptions, suicide notes, graffiti images, gift certificates, log books, medical records and business records are submitted as evidence². The final results in an examination of documents are determined by the quality and quantity of material available to the forensic document examiner for comparison. Known standards must be adequate. One or two standards are generally not enough to identify a writer. The investigator should submit all of the questioned material and as much comparable known material as possible².

It is important to collect enough writing from each person to allow the forensic document examiner to study the range of natural variation in each person's handwriting. Handwriting is a learned process where we practice and improve on our skill. The writing though is a conscious process in the beginning it changes to be subconscious event passing through at least three different phases only to stabilise in the middle age. As we age further it starts to degenerate due to various intrinsic and extrinsic factors^(3,4).

Signature like handwriting is a visuo-motor skill which requires continuous processing of the visual perceptions to execute effectively the fine hand movements. This makes visual inputs very important

for proper writing^(5, 6). Uncorrected refractive errors are the most common cause of reversible blindness in India⁷. Studies from urban India suggest that 49.3 million of those aged >15 years may have refractive errors⁸. Myopia has been reported in some studies as the most common refractive which can be corrected easily⁹.

Considering question documents, the most common way of authenticating the source of a document is by the signature analysis. Signature is a special writing skill developed by an individual for personal use. This fine motor movement (signature) though are learnt initially become more sub-conscious with repeated practice. Even for the sub-conscious execution of the fine motor movements constant visual perceptual inputs are required⁴.

Here we have attempted to catalogue changes in different class characters of one's Signature at different grades of myopia so as to have an authentic objective data. The data thus collected will provide better insight on this relatively less studied area and certainly help the normal variation in question document examination thus aiding in authenticating checks, bomb threats, anonymous letters, prescriptions, suicide notes, medical records and business records etc.

MATERIALS AND METHODS

The study was conducted in Shri Sathya Sai Medical College and Research centre, Ammapettai, Chennai over a period of six months between April - September 2014.. After the Institutional Ethical committee clearance was obtained an advertisement was put up in the college campus asking for volunteers. A total of 100 subjects were selected from faculty, office staff, technical staff and students on first come first serve basis.

The participants were informed of the procedure and purpose of the study and informed consent was obtained in writing. Only subjects with visual acuity of 6/6 were selected for the study. The subjects were asked to write their signature three times in the space provided in the proforma.

Myopia was induced in the participants by giving plus spherical lenses from the trial set starting from +0.5 D power with serial increments of +0.5D up to 4 D as the subjects reported significant diminution of vision preventing them from continuing further . The task was repeated for each of the plus lens given. Pens to perform the task were provided to maintain uniformity in the data collected and avoid error introduced by defective pens.

After the performance of all the tasks the signatures were collected and assessed for a set of class characters. Class characters like font size, orientation, style, curvature, stability, slant, dot character etc were evaluated. For the purpose of the study eight standard variables for the signature were

analyzed repeatedly with every increment of plus lens given. The data was compiled & statistically analyzed using SPSS (Statistical Package for Social Sciences) computer software (version 16).

RESULTS AND DISCUSSION

The sample of the study consisted of 100 (68 male & 32 female) subjects between 18-38 years, with the mean age of the participants being 23.3 yrs. As the study was planned in Chennai most of the participants were Tamil (78%) speaking.

As required in this study eight variables were repeatedly measured in the Signatures with every 0.5 D increment of the plus lens. The changes in the variables were compared to the handwriting character of the subject when the task was performed for normal vision. The difference in their means was studied. To check for the variance and its statistical significance multivariate analysis (MANNOVA) was used. The results of the same for relevant variables are presented here.

Signature Size: Maximum length of one's signature was measured for each of the three signature specimen provided and the average of the three was taken to be the signature size. Signature size at different grades of myopia was compared with the signature size at normal vision and the data is presented in **table no 1 and table no 2**. From the tables it can be observed that the mean size of the signature is more than that at normal vision.

Further in the multivariate analysis showed statistically significant difference in the average signature size of the signatures with serial increments of myopia, $F(335, 145) = 5.203$, $p < .0005$; Wilk's $A = 0.000$. However the extent of change seen in the signature size is inconsistent and variable and can't be used to predict the grade of myopia.

Letter size: For the purpose of handwriting analysis in cursive writing the letters are said to have three zones, usually termed as the upper zone, middle zone and lower zone. Normally this corresponds to the four line book used by children to practice writing. The average size of the letters in ones cursive writing was measured with letters having both upper and lower zone like letters 'L' & 'T'. However in signature the letter size as a whole is of little significance as many people don't follow the normal proportionality of letters to enhance the artistic quotient of the signature. It is more appropriate to consider the proportionality of the individual zones separately. **Table no 3** presents the mean size of the letters in middle zone, Upper zone and lower zone.

The middle zone size is found to be lesser than the actual size with serial increments of myopia. Contrary to this finding the upper zone and lower zone size at different grades of myopia is found to be

significantly more than that at normal vision. Multivariate analysis of showed that this difference is statistically significant (Mid Zone Size- $F(280, 462) = 2.122, p < .0005$; Wilk's $A = 0.002$, Upper Zone- $F(216, 516) = 1.841, p < .000$; Wilk's $A = 0.012$, and lower Zone - $F(248, 490) = 2.119, p < .000$; Wilk's $A = 0.004$.) However the extent of change seen in the signature letter size in different zones is inconsistent and variable and can't be used to predict the grade of myopia.

Space between letters: In standard cursive writing it is found that every person spaces the sentences in a paragraph, words in a sentence and letters in word differently. As can be seen above the size of the signature varies in different people and also in the same person at different grades of myopia. With a calliper the distance between two adjacent letters of the signature was measured and the average of the pairs was taken as the average Space between the letters. The space between letters at different grades of myopia was compared and the data is presented in **table no 4**. From the table it can be noted that the average space between the letters is comparatively higher than that in normal vision thus explaining the larger size of signature. Multivariate analysis of the variables showed that this difference is statistically significant ($F(248, 490) = 6.469, p < .000$; Wilk's $A = 0.000$).

Signature Slope: Unlike in cursive writing, signature need not be written on a horizontal straight line. It is common practice to write the signature in an oblique ascending manner⁴. This gives a peculiarity to the

signature and the slope of the signature can be measured. The slope of the signature has been graded with five degree increments on both sides of the horizontal (0 or 180 degrees). The signature slope of the individual was measured three times and the average of the three was taken to derive the signature slope. **Tables numbering 5 & 6** present the data on percentage of subjects showing change in signature slope at different grades of myopia. From the tables it can be noted that as the grade of myopia increases more number of subjects tend to deviate from their normal signature slope irrespective of what was the initial slope of their signature.

Signature letter slant: In normal cursive writing the letters are written preferably at some acute angle to the horizontal baseline. This improves the speed of writing. In terms of graphology the angle which the letters make with the horizontal can be graded and is an important variable among various class characters of handwriting. Similar approach can also be applied to letters in a signature. As can be seen from **table no 7**, the signature slant clearly changes and the percentage of subjects shoeing a change increases with serial increments of myopia.

We did not find any articles published specifically on the effect of myopia on signature analysis. Most the references are indirect references from graphology. Most studies suggest change in normal handwriting with progressive change in visual acuity. Findings similar to our study are documented by various other researchers in handwriting like Huber et al.⁴, Wilson et al.⁶, Ann Stensaas¹⁰, Ling et al¹¹, William et al¹² & Mischio¹³.

Table 1: Mean size of signature at different grades of myopia.

Signature size	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Normal vision	100	5.00	50.60	22.3665	11.15877	124.518
Signature size 0.5D	100	4.00	50.60	22.2630	11.89422	141.472
Signature size 1D	100	4.00	50.60	20.9610	11.62672	135.181
Signature size 1.5D	100	7.00	50.60	21.4640	10.50740	110.405
Signature size 2D	100	8.00	50.60	21.4930	10.44390	109.075
Signature size.5D	100	9.00	53.60	22.7480	11.14926	124.306
Signature size 3.5D	100	7.00	59.60	22.8480	12.94664	167.615
Signature size 4D	100	9.00	56.60	23.5330	11.94452	142.672

Table no 2: Results of Multivariate (MANNOVA) test for Signature Size with serial increments in myopia

Multivariate Tests						
	Effect	Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.999	6.172E3 ^a	5.000	28.000	.000
	Wilks' Lambda	.001	6.172E3 ^a	5.000	28.000	.000
	Hotelling's Trace	1.102E3	6.172E3 ^a	5.000	28.000	.000
	Roy's Largest Root	1.102E3	6.172E3 ^a	5.000	28.000	.000
Signature size	Pillai's Trace	4.008	1.930	335.000	160.000	.000
	Wilks' Lambda	.000	5.203	335.000	145.301	.000
	Hotelling's Trace	476.089	37.519	335.000	132.000	.000
	Roy's Largest Root	449.993	2.149E2 ^b	67.000	32.000	.000

a. Exact statistic/ b. The statistic is an upper bound on F that yields a lower bound on the significance level./ c. Design: Intercept + signature size

Table 3: Mean size of the letters in Middle zone, Upper Zone & Lower Zone in different Grades of Myopia

Sl/no	Visual acuity level	Mean Signature Mid Zone Size (mm)	Mean Signature upper Zone Size (mm)	Mean Signature lower Zone Size (mm)
1	Normal vision	4.2230	3.7530	3.3820
2	Myopia 0.5 D	4.2000	4.1130	3.3830
3	Myopia 1 D	4.2430	3.5735	3.4360
4	Myopia 1.5 D	3.8445	4.6895	3.5235
5	Myopia 2 D	3.5480	4.2430	3.5030
6	Myopia 2.5 D	3.9280	4.6080	3.9380
7	Myopia 3D	3.8630	3.4580	3.5230
8	Myopia 3.5 D	3.9230	4.6380	3.7030
9	Myopia 4 D	3.6280	3.9180	3.9030

Table 4: Space between letters in different Grades of Myopia.

	N	Minimum	Maximum	Mean	Std. Deviation
Sig space between letters	100	.00	4.60	1.8230	.97679
Sig space between letters 0.5D	100	.00	5.60	1.7430	1.16248
Sig space between letters 1D	100	.00	4.60	1.9680	1.18039
Sig space between letters 1.5D	100	.00	5.60	1.9080	1.12409
Sig space between letters 2D	100	.00	7.60	2.2880	1.59496
Sig space between letters 2.5D	100	.00	5.60	2.0080	1.17780
Sig space between letters 3D	100	.00	8.60	2.5280	1.90178
Sig space between letters 3.5D	100	.00	5.60	2.2280	1.39350
Sig space between letters 4D	100	.00	6.60	2.3380	1.49651

Table 5: Comparison of signature line slope with different grades of myopia.

Different grades of myopia	Induced myopia 0.5D	Induced myopia 1 D	Induced myopia 1.5D	Induced myopia 2 D	Induced myopia 2.5D	Induced myopia 3 D	Induced myopia 3.5D	Induced myopia 4 D
Slope same as that in Normal vision	45	27	26	23	27	12	30	26
Slope changed from that in normal vision	55	63	64	67	63	88	70	64

Table 6: Percentage of subjects who do not show a change in signature line slopes at different grades of myopia.

Different degrees of signature slopes	Induced myopia (0.5D)	Induced myopia (1D)	Induced myopia (1.5D)	Induced myopia (2D)	Induced myopia (2.5D)	Induced myopia (3D)	Induced myopia (3.5D)	Induced myopia (4D)
0/180°	0	0	0	0	100	0	0	0
5°	0	0	0	0	0	0	0	100
10°	30.7	0	0	34.6	0	19.2	0	15.4
15°	68.8	33.4	33.4	50	36.1	33.4	58.4	22.2
20°	0	0	0	0	30.7	0	30.7	30.7
25°	100	100	0	50	0	0	50	50
-5°	100	100	100	0	0	0	0	0

Table 7: Comparison of signature letter slant at different grades of myopia.

Different grades of myopia (n=100)	Induced myopia 0.5D	Induced myopia 1 D	Induced myopia 1.5D	Induced myopia 2 D	Induced myopia 2.5D	Induced myopia 3 D	Induced myopia 3.5D	Induced myopia 4 D
Letter slant same as that in Normal vision	68	54	59	58	54	64	59	37
Letter slant changed from that in normal vision	32	46	41	42	46	36	41	63

As stated earlier, visual inputs contribute significantly to the perceptual skills necessary for writing. The visual-motor coordination is the ability to match motor output with visual input. It is a complex process where integrating information from the visual and the motor systems is necessary to reach the optimum movement pattern that is visually accurate and saves energy¹⁴. Visually impaired persons also have difficulty in judging the form, length, and location of strokes. Partial vision can provide a few guides and the availability of these reference points may determine the quality of the writing or lettering. Various changes like misalignment of letters or words with one another and distortion of the written content with respect to a ruled or implied baseline are seen. There is some increase in letter sizes compared to the previous handwriting^(4, 6,10,11,12 & 13).

The increase in the signature size can be explained by the findings of table no 4 where it is found that the spacing between letters of the signature increases with change in the visual acuity. But unlike findings in the previous study the change size of the letters in different zones is inconsistent. Middle zone size seems to be decreasing compared to the upper and lower zones which increase with change in visual acuity. Signature as suggested by William et al¹², is a product of repeated practice and visual impairments might not have a significant influence on its execution as it becomes more of a subconscious affair. Sufficient published literature to corroborate these preliminary findings is not available and hence more extensive studies to further understand this process need to be attempted.

CONCLUSION

From the findings of the study it can be concluded that myopia significantly influence the signature and any change in visual acuity would induce corresponding changes in the signature characters. There is increase in signature size, signature space between letters where as the Middle zone letter size decrease in different grades of myopia. The signature slope and letter slant also changes in most subjects with change in the visual acuity. The changes are not linear and can't be used to predict the grade of myopia but can be used as parameters suggestive of refractive error. These changes must also be kept in mind while evaluating question documents.

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