TYPOGRAPHIC DIMENSIONS AFFECTING THE LEGIBILITY OF HINDI PRINT:

A Factorial Experiment

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(With a very rapid quantitative expansion in the sphere of education, we in India need effective measures to improve the quality of the learning experience of the students. The most vital skill for the learner, whether at school or at college, is that of reading.

This article deals with it through the experimental eye. It opens up large vistas of comparable work in various regional languages of India. This would lead to the preparation of reading material in a better look, to facilitate quicker reading with a maximum scope for comprehension and subsequent application.

The studied investigation by Shri B. S. Bhagoliwal is decidedly a sterling contribution to the opening of newer channels of purposeful research work.　— *Editor*)

Legibility studies have been made in English to study the influence of various typographical dimensions. The pioneers in such studies have been Paterson and Tinker (6) in the U.S.A., and Burt (2) in U.K. They have also developed specifications of optimum dimensions for the use of typographers, publishers and printers, in order to make reading swifter, easier and more comprehensible. Poulton (7) has summarised their results with those of Luckiesh and Moss, and has pointed out the limitations in their interpretations, e.g., criterion of readability, lack of statistically significant differences, use of a standard condition for the comparison of various conditions, and the difficulties of interpretation due to the interaction of variables. Most of the above works relate to the changes in legibility when varying one or at the most, two factors only, while they all agree that interactions among the various typographical factors are very significant. Perhaps most important for education and communication in India is the fact that no experimental work has been reported on development of specifications for Hindi Print.

The Present Study

In this study an attempt has been made to show the influence of some of the typographical dimensions on the legibility of Hindi Print. In this study the words "legibility" and "readability" have been interchangeably used to mean "ease and speed of reading printed material at a natural reading dis-

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tance" (6)   According to Burt, "The legibility of a page of print is the resultant of many different factors—the size, the form, the thickness or 'boldness' of letters, the width of the line, the spacing between successive words, the distance between successive lines, the texture of the paper, the ink, the presswork, the lighting, and what is too often overlooked, the intrinsic interest of subject matter itself" (2, p. 5).   For the present study, only three main variables viz. type size, line width, and space between lines or 'leading' have been taken into consideration and other factors were kept constant and optimum as far as possible.

Incidentally, during the search for an appropriate design to study the effects of a number of simultaneous changes in the three variables, a review was made of the various higher order factorial designs as discussed by Cochran and Cox (3), and Lindquist (4).   Interest in the project also increased because of a remark by Lindquist, "The designs that have been presented here as examples have not, to the writer's knowledge, ever been employed in educational and psychological research, but they suggest still further designs that might have interesting possibilities in this field".   (4, p. 304).   Hence it also became necessary to explore the workability of this factorial design for the present problem and finally, a 3^4 factorial design with one-third replication was developed for this purpose using subjects as blocks.

Method

The various methods employed by the previous investigators to determine the legibility of type have been broadly classified by Burt (2, p. 4) as follows.

1.   Ease of reading letters, words, or sentences judged by the distance at which they can be read.

2.   Accuracy of reading letters or words, with brief tachistoscopic exposure.

3.   Speed of reading passages of prose, when the reader's aim is to grasp the content of the passages.

4.   The observation of eye-movements, eye-blinking, and other objective symptoms.

On the basis of considerations similar to those described by Burt, the method employed for measuring legibility in this study was that of 'speed of reading passages of prose when the reader's aim is to grasp the content of the passages', (2, p. 4). A marked deviation was made from Burt's study in that comprehension was not measured by means of a questionnaire; passages were selected such as to be markedly easy in comprehension and the subjects were asked to read the passages aloud so that their lack of comprehension could be

measured on the basis of the mistakes committed in reading. Again, as Burt has noted, 'differences in legibility and fatiguability may not appear during the first few minutes' (2, p. 5); longer passages were chosen so as to approximate 250 words per passage.

Experimental Passages

In order to estimate individual differences the same passage or passages should be read by each individual; to control the effect of learning, there should be at least three different but equivalent passages to be read by each individual. To keep the factor of interest within control it was decided to select passages of equal ease of comprehension. More than thirty short stories were analysed to determine their "Reading Ease Index" on the basis of the readability formulae as applied to Hindi by Bhagoliwal (1). Then four passages were selected so as to have maximum comprehensibility, yet having a very similar Reading Ease Index.

Three of these passages were printed in modern style Roman of Hindi mono-type in 27 different combinations of the $3 \times 3 \times 3 \times 3$ design as specified in table I, and the fourth passage was printed in hand-composed Hindi-Italic with typographical dimensions different from any of the various 27 combinations used for the experimental passages. This last passage was used as a control passage to be read by the subject before any of the experimental passages. The colour and texture of the paper, the ink, the press-work were also kept constant for all these 28 combinations of the four passages.

Values of the different dimensions may be summarized as follows:

Typographic Dimension	Treatment Level		
	0	1	2
B Point Size	12 pt	14 pt	16 pt
C Line Width	3½"	4"	4½"
D Inter-liner Space	Solid	1 lead	2 lead

To illustrate the type used and the typographic dimensions, Figure 1 presents portions from three passages: (i) 12 pt, 3½" line width, set solid; (ii) 14 pt, 4" line width, 1 lead; and (iii) 16 pt, 4½" line width, 2 lead.

Experimental Conditions: In order to control other factors and keep them at the optimum level, the experiment was carried out in a dark room having a general illumination from an artificial source, very high from the floor, to avoid glare in the visual field of the subject. Also extra illumination to the reading area was provided with a 100 watt tungston white bulb, so as to give a controlled and concentrated total brightness to the task area of approximately 30-35 foot-candles. The subjects were to sit on a

fixed chair in front of a table on the other side of which the experimenter was to take his seat. The reading passage was placed on a stand at an angle of 45° from the horizontal level of the table, as suggested by Tinker (8). The stand was of the size of 18″ × 20″ to cover at least 60° of the central portion of the visual field as specified by Luckiesh (5, p. 219). The stand was placed on the table as to be parallel to the edge of the table towards the subject's seat and at a distance of approximately 14″ from his eyes (5, p. 297). Thus the whole experimental set up was according to the optimum specifications of Luckiesh (5).

Subjects

The subjects were chosen in sets of nine, each set from the same section of class VIII. Their mother tongue was Hindi and they were matched in each set on age (12-15 years) and their achievement in Hindi. Also they were tested first on snellen chart in Hindi, for a vision of 20/20 or more from a distance of 20 ft. from the chart. Those subjects who had some disability in reading or speaking, e.g., stuttering, were excluded from the experiment.

Administration of the Test

The subjects were randomly assigned to each of the nine sets of combinations and the combinations were also randomised for each subject. First they were given the control passage to read aloud and their time of reading the passage and the errors committed in reading were noted by the experimenter using a stop-watch. Then they were asked to read the three experimental passages one by one according to the experimental design (Table 1). The time taken by them for each passage and the errors committed were noted by the experimenter with a stop-watch. The following instructions were given to the subjects in Hindi before starting the experiment.

"I will give you four passages one by one to read. It will be a test of your speed of reading and understanding Hindi accurately. Read the passages a bit aloud so that I can hear you. Also read as fast as you can, but be careful not to make any mistakes. I will note down the time taken by you to read each of the passages and the mistakes committed. Start only when I ask you to do so".

With the above procedure two replication of the design were made, thus taking observations on 18 students in all. The design used was Plan 6A, 18 (3, p. 290).

Analysis and Results

The time taken by the subjects in reading each passage was converted for a standard 1000 words to equalise for unequal number of words in the

four passages. These standard timings along with the subject's age and achievement-scores in Hindi and the combinations of the passages on which the timings were noted are given in table 2.

The number of errors committed in the reading of different passages are not presented as they were negligible, being zero or so, with a maximum of five per passage.

The data were analysed by the analysis of variance technique. Table 3 presents the variations due to each of the factors and their interactions along with their significance at ·01 or ·05 level. The analysis has been outlined by Cochran and Cox (8, pp. 271-273) for this experimental design.

Discussion

The results presented in table 3 show that all the two-factor and three-factor combinations are significant, and the main effect of one factor (D) is also significant. Examination of the results shows that increasing the space between lines (D) does not increase the legibility of the print. On the other hand we find in this experiment greater legibility when the type is set-solid or with one leading as indicated by lesser reading time for set-solid (D_0) and single space between lines (D_1) then when the inter-liner space is doubled (D_2).

All the two-factor interactions are significant at ·05 level. There are optimum values for B_2C_1 combination i.e. 16 pt. type is definitely more legible than 10 pt. or 12 pt. size and that too when presented in medium column-width (4″), the difference being significantly greater when the length of the line is either reduced to $3\frac{1}{4}″$ or increased to $4\frac{1}{2}″$. Similarly 16 pt. type size was found most legible with single space leading as compared to any other combinations of type-size and leading as revealed by the least time taken by the B_2D_1 combination. Again the C_0D_0 combination or the shortest line of $3\frac{1}{4}′$ width set-solid was on the whole more legible than any of the other combinations of line-width and leading. The three factor interaction was significant even at ·01 level.

Among the various combinations used for this experiment, the optimum legibility for different type-sizes was as follows, 12 pt. size was most legible in $4\frac{1}{2}″$ line set at single space; 14 pt. type-size was most legible with the shortest line (3″) set solid; and 16 pt. type-size took least time in reading when presented in 4″ line width with double space.

Summary and Conclusions

The objective of this experiment was two-fold:

1) To study the influence of some typographical dimensions and their interactions on the legibility of Hindi measured by the speed of reading the passages accurately at a normal reading distance; and

2) To see the workability of a high order factorial design for this purpose and other similar problems in psychology and education.

For this purpose a $3 \times 3 \times 3 \times 3$ factorial design was devised for one-third replication, using subjects as blocks. Three main typographical dimensions viz. type-size, line width, and 'leading' or interliner space, were presented in 27 specified combinations to the subjects arranged in sets of nine, on the basis of their age and achievement in Hindi. The whole experiment was carried out under strictly controlled conditions. Two sets of observations were taken up on one-third-replication of the design.

The results, when analysed by the analysis of variance technique, indicated all two-factor interactions significant at ·05 level and the third-order interaction significant at ·01 level. Also the main effects of one factor were significant. This clearly demonstrates the successful workability of this design for the project.

In terms of specific recommendations for Hindi type, it should be noted that double-spaced printing was found less legible than either the set-solid or single spaced arrangement. Optimum values for two factor interactions were given by (a) 16 pt. type printed in 4″ length, (b) 16 pt. type set with single space between lines, and (c) 3½″ lines set solid. Optimum values for different type sizes are also discussed here but they should not be taken as generalisations because of the small sample size and the limitations imposed due to the small number of variations studied in this factorial design.

Acknowledgements

REFERENCES

(1) Bhagoliwal, B.S.: Readability formulae: Their reliability, validity and applicability in Hindi. *J. Educ. Psychol.*, 1961, 19, 13-26.

(2) Burt, C.: *A Psychological Study of Typography.* Cambridge, Cambridge Univ. Press. 1959.

(3) Cochran, W. G. and Cox G. M.: *Experimental Designs*, 2nd ed., New York, Wiley, 1957.

(4) Lindquist, E. F.: *Design and Analysis of Experiments in Psychology and Education.* Boston, Houghton Mifflin, 1953.

(5) Luckiesh, M.: *Light, Vision and Seeing*, New York, D. Van Nostrand, 1954.

(6) Paterson, D. G. and Tinker, M. A.: *How to Make Type Readable*. New York, Harper, 1940.

(7) Poulton, E. C.: A note on printing to make comprehension easier, *Ergonomics*, 1960, 3, 245-248.

(8) Tinker, M. A.: Effect of slanted text upon the readability of print, *J. Educ. Psychol.* 1954, 45.

Table 1

Treatment Combinations for Passages in Terms of Type Size (pt).
Line Width ("), and Leading

Subject	Passage I	Passage II	Passage III
1	12pt. × 3½" × solid	14pt. × 4" × 2 lead	16pt. × 4½" × 1 lead
2	16pt. × 3½" × 1 lead	12pt. × 4½" × solid	14pt. × 4½" × 2 lead
3	14pt. × 3½" × 2 lead	16pt. × 4" × 1 lead	12pt. × 4½" × solid
4	12pt. × 4½" × 1 lead	14pt. × 3½" × solid	16pt. × 4" × 2 lead
5	16pt. × 4½" × 2 lead	12pt. × 3½" × 1 lead	14pt. × 4" × solid
6	14pt. × 4½" × solid	16pt. × 3½" × 2 lead	12pt. × 4" × 1 lead
7	12pt. × 4" × 2 lead	14pt. × 4½" × 1 lead	16pt. × 3½" × solid
8	16pt. × 4" × solid	12pt. × 4½" × 2 lead	14pt. × 3½" × 1 lead
9	14pt. × 4" × 1 lead	16pt. × 4½" × solid	12pt. × 3½" × 2 lead

Table II

Tabulation of Reading Time by Subject and Passage

Student Number	Age	Marks in Hindi	Control Passage Time (minutes)	Passage I: Corrected for 1000 words Combinations* Time (minutes)		Passage II: Corrected for 1000 words Combinations* Time (minutes)		Passage III: Corrected for 1000 words Combinations* Time (minutes)	
Set I									
1	12+	74	2·78	0000	8·59	1112	6·57	2221	8·13
2	14+	83	1·74	0201	4·81	1010	4·87	2122	4·56
3	13+	63	1·75	0102	5·77	1211	5·08	2020	5·63
4	13+	74	1·69	0021	4·36	1100	4·45	2212	4·52
5	15+	61	2·28	0222	6·87	1001	5·85	2110	6·15
6	14+	89	1·90	0120	3·92	1202	4·66	2011	5·83
7	13+	90	1·80	0012	4·64	1121	5·00	2200	4·37
8	13+	81	2·40	0210	8·08	1022	7·03	2101	7·54
9	13+	72	1·80	0111	5·36	1220	4·83	2002	5·12
Set II									
10	13+	65	1·97	0000	6·01	1112	5·25	2221	6·27
11	13+	65	2·60	0201	7·49	1010	8·18	2122	8·21
12	15+	54	2·20	0102	5·77	1211	5·64	2020	6·55
13	14+	65	2·27	0021	5·77	1100	5·51	2212	5·52
14	13+	66	2·16	0222	5·88	1001	5·38	2110	6·07
15	12+	70	2·09	0120	5·98	1202	5·81	2011	6·45
16	12+	66	2·19	0012	6·15	1121	6·36	2200	6·39
17	13+	67	2·50	0210	7·15	1022	5·17	2101	6·35
18	12+	63	2·05	0111	5·26	1220	4·87	2002	4·80

*Treatment combinations:

A 1st Column — Passage
B 2nd Column — Point Size
C 3rd Column — Line Width
D 4th Column — Inter Liner Space.

Table III

Analysis of Variance Summary
Table for Reading Rate of Passages in Hindi

Source of Variation[***]	d.f.	Sum of Squares	Mean Square	F Ratio
Within students	36	9·9081	·2752	
B	2	0·1951	·09755	·7715
C	2	0·1265	·06325	·5002
D	2	0·9254	·46270	3·6594*
BC	2	0·8920	·44600	3·5274
B D_2	2	1·1937	·59685	4·7204*
C D_2	2	1·2548	·62740	4·9620*
A = B C D	2	2·1775	1·08875	8·6108**
A C = B C_2 D	2 ⎱	1·1155	0·27888	2·2056
A C_2 = B C_2 D_2	2 ⎰			
Error (i)	18	2·0276	0·12644	
Between students	17	56·4120		
B C_2	2	0·3626	0·1813	0·0496
B D	2	5·8683	2·93415	0·8032
C D	2	9·5679	4·78395	1·3095
B C D_2	2	7·7339	3·86695	1·0585
Blocks (Replication)	1	2·5134 ⎱		
Error (ii)	8	30·3659 ⎰	3·65326	
Total	53	66·3201	1·2513	

    * $P < ·05$ ($F_{2,18} = 3·55$)

    ** $P < ·01$ ($F_{2,18} = 6·01$)

    ***   Refer to text or Table II for identification of letters

आदमी के पास है । भारी पग्गड़ और मशीन से मुझे अधगंजे सिर फिर
एक साथ घूम-फिर रहे हैं । वैसा ही—ठीक वैसा ही शोर है । ठीक
तरह कुछ सुनाई नहीं देता। बहुत सी आवाजें एक साथ फेंकी जा रही हैं।

(i)

उस पहले दिन की बात सोचते हुए आज, दस साल याद भी, उसे
सरदी-सी लगती है । लगा, जैसे मछली की तरह उसे बरफ में दबा दिया
गया हो और वह क्षण आ गया हो, जब खून जमने लगता है । हृदय
बैठने लगता है, जैसे मार्फिए के अनगिनत इंजेक्शन लगा दिए गए हों ।
पर आज ये अधजवान चीलें और बूढ़े बाज फिर क्यों आये हैं ? आज दस
वर्ष बाद, क्या फिर कुछ उस दिन जैसा होनेवाला है ? नहीं...नहीं...
उस जैसा कुछ भी आज कैसे हो सकता है ! शरीर पर शहद लपेट कर
उसे लाल मुँह वाले चींटों के बीच आज नहीं फेंका जा सकता । फिर ?
ये मीगी मसें और अनेक मोटी पगड़ियाँ उस के घर के नीचे आज दोबारा

वसा ही शोर है। ठीक तरह कुछ सुनाई नहीं देता। बहुत-सी
आवाजें एक साथ फेंकी जा रही हैं ।

(ii)

उस पहले दिन की बात सोचते हुए आज, दस साल याद भी, उसे
सरदी-सी लगती है । लगा, जैसे मछली की तरह उसे बरफ में दबा
दिया गया हो और वह क्षण आ गया हो, जब खून जमने लगता है ।
हृदय बैठने लगता है, जैसे मार्फिए के अनगिनत इंजेक्शन लगा दिए
गए हों । पर आज ये अधजवान चीलें आर बूढ़े बाज फिर क्यों आये
हैं ! आज दस वर्ष बाद, क्या फिर कुछ उस दिन जैसा होनेवाला है !

(iii)

उस पहले दिनकी बात सोचते हुए आज, दस साल बाद भी, उसे
सरदी-सी लगती है । लगा, जैसे मछली की तरह उसे बरफ में दबा
दिया गया हो और वह क्षण आ गया हो, जब खून जमने लगता है ।
हृदय बैठने लगता है जैसे मार्फिए के अनगिनत इंजेक्शन लगा दिए गए
हों । पर आज ये अधजवान चीलें और बूढ़े बाज फिर क्यों आये हैं ?
आज दस वर्ष बाद, क्या फिर कुछ उस दिन जैसा होनेवाला है ?

Figure 1. Samples from three passages in Hindi illustrating typographic
dimensions of point size, line width, and inter-liner space: sample (i) 12 pt.,
3·5″ line width, set solid; sample (ii) 14 pt., 4″ line width, 1 lead; and sample
(iii) 16 pt., 4·5″ line width, 2 lead.