
Technical Report TR.12.089

**Legibility Tests of Two Character
Sets for a Schools Computer**

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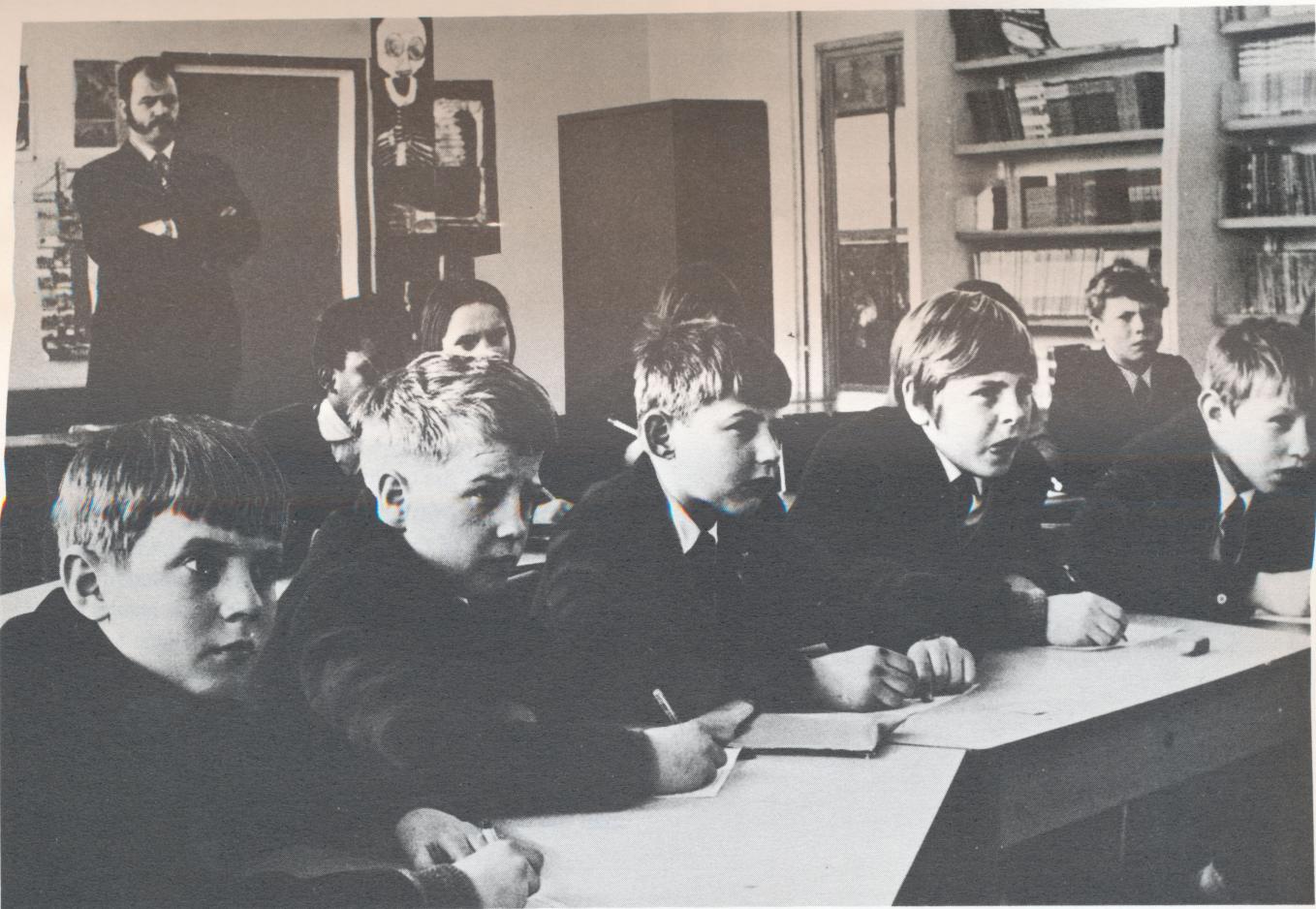
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Abstract

Two alphanumeric character sets were designed specifically for television display with a schools computer. This technical report explains the legibility tests that were carried out, and the results that were obtained when schoolchildren were shown the two character sets.

The legibility of the two sets of characters was tested by showing them on a television screen to schoolchildren in typical school classroom environments. The results of the first test were analysed and modifications made to the character sets accordingly. The revised character sets were shown again.

Once again the results of the legibility tests were analysed. However, no changes were made to the character sets. The report concludes that one character set is more legible than the other.



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Legibility tests were carried out on two different character sets. Character set A is illustrated in Figure 1 and character set B in Figure 2.

Character Set Design

Both character sets were designed in a 5×7 matrix of square elements for display on any domestic TV screen.

Character set B was sloped to the right by one element (Figure 3). Details of element size and lines per character, which apply to both character sets, are also shown in Figure 3.

Test Subjects

The subjects used for the tests were a group of boys from a

private school, and a group of boys and girls from a state school.

Test Environment

The test environment was a school classroom, considered typical of most school classroom situations, i.e. there was no special equipment or seating arrangements for using educational television.

The seating arrangements and position of the TV screen for the test is shown in Figure 4. This arrangement is based, as far as the prevailing classroom conditions would allow, on the recommendations contained in the report by Neal¹.



Figure 1. Character Set A used in Legibility Test 1



Figure 2. Character Set B used in Legibility Test 1

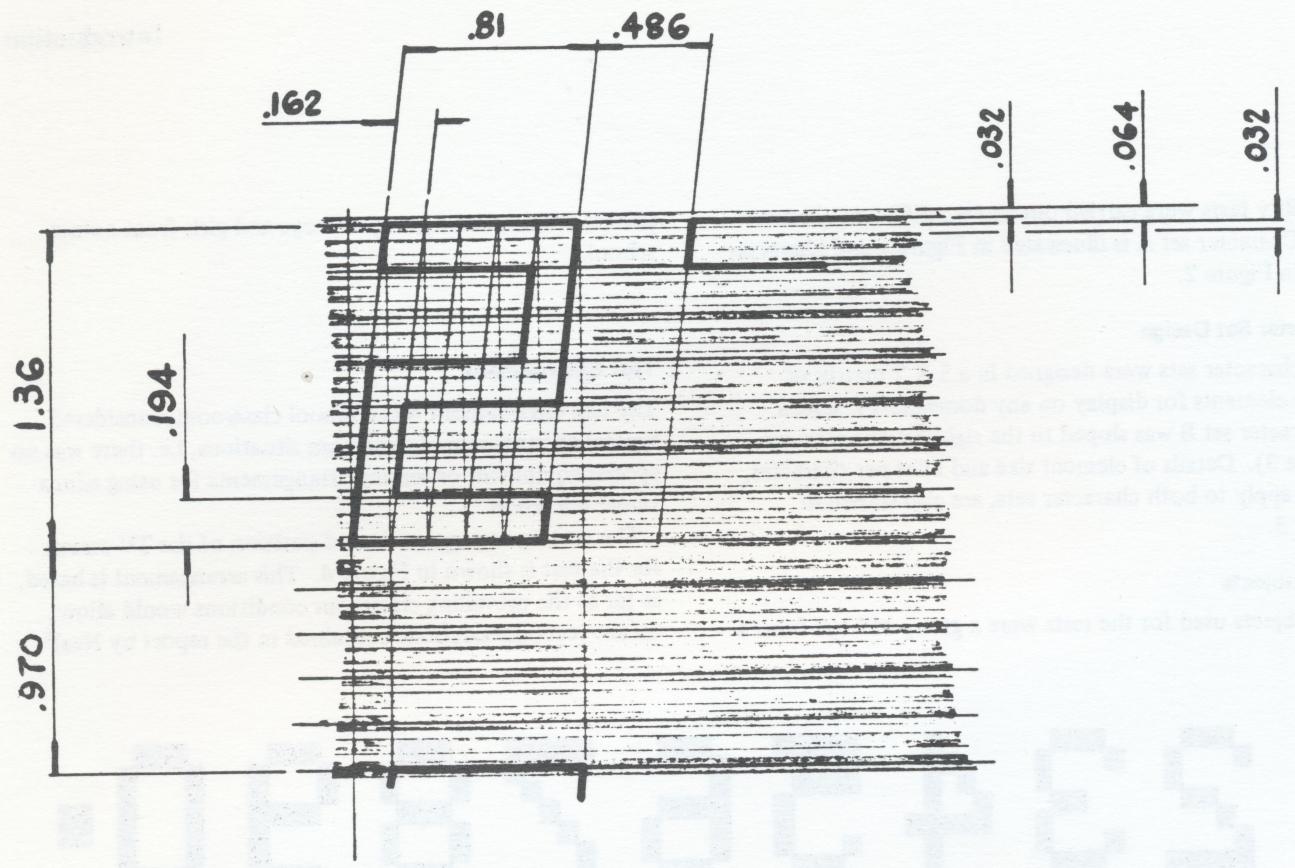
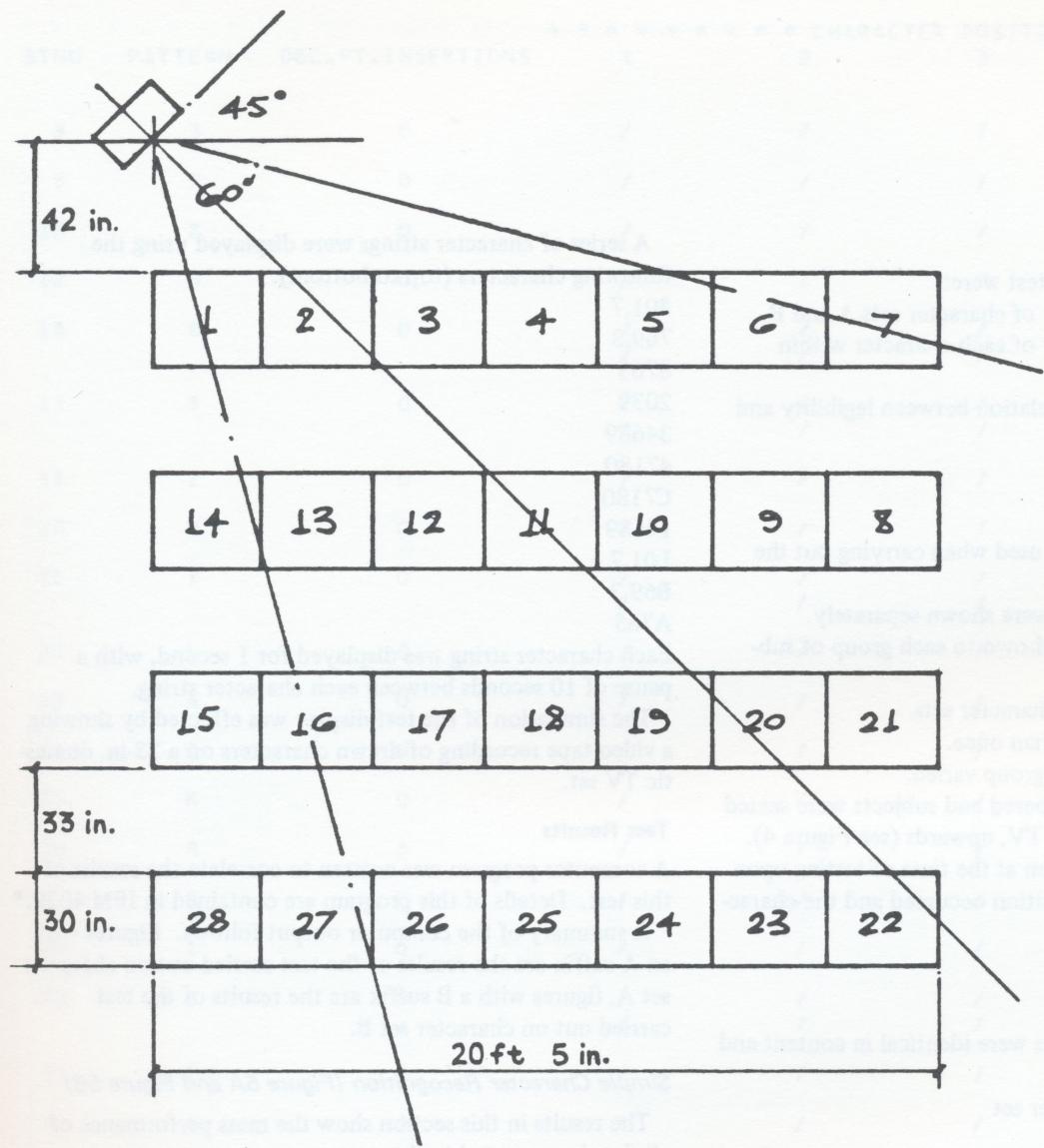


Figure 3. Format of Character



Note:- 23-in. TV screen used. Distance from floor to centre of screen 60 in.

Figure 4. Seating Arrangements and Positioning of TV Screen

Legibility Test 1

Test Objectives

The objectives of the legibility test were:

1. To test the relative legibility of character sets A and B.
2. To test the relative legibility of each character within each set.
3. To see if there was any correlation between legibility and seat position.

Test Procedures

The following procedures were used when carrying out the tests:

1. The character sets A and B were shown separately.
2. Only one character set was shown to each group of subjects.
3. No group was shown both character sets.
4. No group was tested more than once.
5. The number of subjects per group varied.
6. Each seat position was numbered and subjects were seated from position 1, i.e. nearest TV, upwards (see Figure 4).
7. Each subject was given a form at the time of testing upon which to record the seat position occupied and the characters viewed.

The Legibility Tests

The tests for both character sets were identical in content and sequence.

To begin the test the character set

1 2 3 4 5 6 7 8 9 0 .

A B C I K L R

as shown in Figure 1 or 2, was displayed for 60 seconds to allow the subjects to familiarize themselves with the peculiarities of the character forms.

A series of single characters were then displayed using the following characters (left to right):

6 1 3 5 9 8 7 0 4 2 3 6 8 0 4 1

5 2 7 9 I L A C K R B K I B C A L R.

Each single character was displayed for $\frac{1}{2}$ second, with a pause of 10 seconds between each character.

A series of character strings were displayed using the following characters (top to bottom):

801.7

769.3

8765

2039

34689

47180

C7180

14689

L01.7

B69.3

A765

Each character string was displayed for 1 second, with a pause of 10 seconds between each character string.

The simulation of the test display was effected by showing a video tape recording of drawn characters on a 23-in. domestic TV set.

Test Results

A computer program was written to correlate the results of this test. Details of this program are contained in IFM 4029.*

A summary of the computer output follows. Figures with an A suffix are the results of the test carried out on character set A, figures with a B suffix are the results of the test carried out on character set B.

Simple Character Recognition (Figure 5A and Figure 5B)

The results in this section show the mass performance of all the classes tested in this group.

The patterns and statement numbers (ST NO) represent the displayed character string and its presentation number respectively. An entry under DEC. PT. INSERTIONS indicates the total number of times decimal points were inserted erroneously.

Entries in one of the five character positions show the total frequency of misinterpreted characters, e.g., 1-'0' means that the character 3 was misinterpreted once as being a zero.

* Internal File Memorandum (Hursley Laboratories)

STNO	PATTERN	DEC.PT.	INSERTIONS	CHARACTER POSITIONS				
				1	2	3	4	5
			/					1-07*
39	34689	5		3-02*		1-03*	1-02*	1-06*
					2-09*	3-09*	3-09*	1-05*
						2-06*	2-06*	1-04*
						1-05*	1-05*	1-00*
						2-03*	2-03*	1-03*
						1-07*	1-07*	
						1-04*	1-04*	
40	47180	5		1-0L*		1-06*		1-09*
							1-00*	
41	C7180	1		2-06*		1-0L*		1-06*
				2-00*				1-09*
				1-01*				
42	I4689	1		45-01*		1-01*	1-07*	3-06*
						1-01*	1-09*	1-02*
								3-07*
								1-01*
								2-04*
								2-00*
								1-03*
43	L01.7	0		1-01*				2-00*
								2-01*
44	B69.3	0		1-0A*			1-08*	1-01*
				1-06*			1-03*	4-06*
				7-08*			1-07*	1-02*
							1-00*	3-07*
45	A765	7	/		2-08*		1-01*	1-00*
			/				1-04*	

Figure 5A (Part 2). Results of Simple Character Recognition using Character Set A

STNO	PATTERN	DEC.PT.	INSERTIONS	CHARACTER POSITIONS				
				1	2	3	4	5
2	1	0		/	/	/	/	2-1T ⁰ 1-2 ⁰ 2-7 ⁰
6	8	0		/	/	/	/	3-1B ⁰
7	7	0		/	/	/	/	1-1I ⁰
8	0	0		/	/	/	/	1-8 ⁰
10	2	0		/	/	/	/	7-5 ⁰ 1-8 ⁰
12	6	0		/	/	/	/	2-5 ⁰
13	8	0		/	/	/	/	4-8 ⁰
14	0	0		/	/	/	/	1-8 ⁰ 2-1D ⁰
16	1	0		/	/	/	/	2-1T ⁰ 1-1L ⁰ 1-1I ⁰ 1-7 ⁰
17	5	0		/	/	/	/	1-5 ⁰ 1-3 ⁰
18	2	0		/	/	/	/	1-5 ⁰ 7-5 ⁰ 1-7 ⁰
19	7	0		/	/	/	/	1-1T ⁰
21	I	0		/	/	/	/	1-1T ⁰ 8-1 ⁰
23	A	0		/	/	/	/	5-1R ⁰
24	C	0		/	/	/	/	1-1L ⁰ 2-1H ⁰
25	K	0		/	/	/	/	36-1H ⁰ 1-1A ⁰
26	R	0		/	/	/	/	9-1A ⁰
27	B	0		/	/	/	/	1-1R ⁰ 5-8 ⁰ 1-1H ⁰
28	K	0		/	/	/	/	35-1H ⁰ 1-18 ⁰
29	I	0		/	/	/	/	1-1T ⁰ 4-1 ⁰
30	B	0		/	/	/	/	6-18 ⁰
31	C	0		/	/	/	/	1-1I ⁰
32	A	0		/	/	/	/	7-1R ⁰

Figure 5B (Part 1). Results of Simple Character Recognition using Character Set B

STNO	PATTERN	DEC.PT.	INSERTIONS	CHARACTER POSITIONS				
				1	2	3	4	5
34	R	0		/	/	/	/	4-18 1-19
35	801.7	0	19-1B 1-L 1-9 1-0	1-A 7-T 4-L 1-B	1-A 7-T 4-L 1-B	1-A 7-T 4-L 1-B	1-6 5-L 3-T 1-8 1-4 3-1 1-9	1-6 5-L 3-T 1-8 1-4 3-1 1-9
36	769.3	0		1-19 1-8 1-3 1-9 1-1 1-8	1-8 1-7 1-0 1-1 1-8	1-6 1-7 1-0 1-1 1-8	1-5 1-8	1-5 1-8
37	8765	1		/	3-B 1-5		2-7	2-9 1-3 1-8
38	2039	3		/			1-8	1-1 1-7 1-B
39	34689	2		1-8		5-5 1-0 1-3 1-5 1-8 1-1 1-4	1-7 1-3 1-5 1-9 1-1 1-4	2-7
40	47180	1		2-7		1-L 3-T 1-I	2-R 1-9 1-D	1-4 1-D
41	C7180	0		1-6	4-T 4-L 1-1	2-L 3-T 1-4	1-L 1-C 1-B 3-6 1-4 1-7	2-9 1-8 2-6
42	14689	1		39-1	1-1	3-5 1-7	1-4	4-7 1-5 1-1
43	L01.7	0		1-7 1-T 2-1		17-T 1-I		3-L 1-T 2-0 2-2 1-1 1-6
44	869.3	0		34-8 1-6 1-3 1-7	1-0 1-3 1-5 1-C 1-4	5-7 1-8		1-6 2-7 1-8 1-2
45	A765	1		/	1-8 3-R 1-3	1-Z 1-5	2-3 1-5	1-9 1-6 1-3 1-8

Figure 5B (Part 2). Results of Simple Character Recognition using Character Set B

Incidence of Mistakes (Figure 6A and Figure 6B)

This section shows the total incidence of mistakes as a function of a particular character in the adopted character set.

The frequency of occurrence indicates the total number of times the character was displayed on the TV screen.

The normalized percentage is derived from the formula

$$\frac{\text{total mistakes}}{\text{frequency of occurrences} \times \text{total no. of subjects}}$$

The total number of subjects tested using character set A = 72
The total number of subjects tested using character set B = 57

CHARACTER	FREQ.OF OCC	TOTAL MISTAKES	NORM %	INTERPRETATIONS
2	3	2	0.925	2-13
3	6	20	4.629	1-11 4-6 3-0 5-2 4-7 2-8 1-5
4	5	2	0.555	1-11 1-11
5	4	6	2.083	2-13 1-6 1-7 1-0 1-9
6	8	8	1.388	2-17 2-13 2-19 1-8 1-11
7	9	11	1.697	1-11 2-0 1-0 1-6 4-1 1-4 1-9
8	8	22	3.819	6-16 1-2 6-19 2-10 2-15 2-17 2-13 1-4
9	7	27	5.357	2-11 1-2 3-8 5-7 1-6 4-3 1-5 4-4 4-0 1-0K
0	7	2	0.396	1-9 1-6

Figure 6A (Part 1). Incidence of Mistakes using Character Set A

CHARACTER	FREO.OF OCC	TOTAL MISTAKES	NORM %	INTERPRETATIONS
A	3	4	1.851	3-8
B	3	12	5.555	1-6 2-A 1-6 9-8
C	3	7	3.240	- 3-6 3-0 1-1
I	3	63	29.166	62-1 1-B
K	2	1	0.694	1-1
L	3	2	0.925	2-1
R	2	1	0.694	1-8

Figure 6A (Part 2). Incidence of Mistakes using Character Set A

CHARACTER	FREQ.OF OCC	TOTAL MISTAKES	NORM %	INTERPRETATIONS
1	6	52	15.204	1-*A* 34-*T* 8-*L* 3-*I* 1-*B* 1-*2* 3-*7* 1-*4*
2	3	17	9.941	14-*5* 1-*S* 1-*8* 1-*7*
3	6	9	2.631	1-*5* 1-*6* 2-*7* 3-*8* 1-*8* 1-*2*
4	5	3	1.052	2-*7* 1-*1*
5	4	10	4.385	1-*S* 3-*9* 1-*6* 3-*3* 2-*9*
6	8	27	5.921	12-*5* 2-*0* 2-*8* 3-*7* 5-*3* 1-*0* 1-*4* 1-*9*
7	9	38	7.407	2-*6* 9-*T* 12-*L* 2-*0* 1-*Z* 2-*2* 1-*8* 1-*4* 6-*1* 2-*9*
8	8	51	11.184	32-*8* 2-*7* 2-*L* 1-*C* 1-*3* 2-*5* 3-*6* 3-*9* 1-*1* 3-*4* 1-*0*

Figure 6B (Part 1). Incidence of Mistakes using Character Set B

CHARACTER	FREQ.OF OCC	TOTAL MISTAKES	NORM %	INTERPRETATIONS
9	7	22	5.513	13- "7" 3- "1" 1- "6" 1- "P" 1- "0" 2- "8" 1- "5"
0	7	12	3.007	1- "A" 1- "B" 1- "4" 2- "9" 2- "8" 3- "D" 2- "6"
A	3	17	9.941	15- "R" 1- "8" 1- "3"
B	3	50	29.239	45- "8" 1- "R" 1- "6" 1- "3" 1- "7" 1- "H"
C	3	5	2.923	1- "L" 1- "1" 1- "6" 2- "H"
I	3	53	30.994	51- "1" 2- "T"
K	2	73	64.035	71- "H" 1- "8" 1- "A"
L	3	4	2.339	1- "7" 1- "T" 2- "1"
R	2	14	12.280	13- "A" 1- "9"

Figure 6B (Part 2). Incidence of Mistakes using Character Set B

Positional Correlation (Figure 7A and Figure 7B)

The results given in the Figures show any correlation between the position of the pupil in the classroom and the legibility of the characters in the character set.

The entries in each seat position represent the total number of times the seat was occupied divided by the product of the number of times the seat was occupied and the frequency of occurrence of the character.

OVERALL PERFORMANCE							
1	2	3	4	5	6	7	
0.027	0.027	0.010	0.013	0.013	0.041	0.010	
14	13	12	11	10	9	8	
0.003	0.027	0.027	0.013	0.027	0.027	0.027	
15	16	17	18	19	20	21	
0.069	0.013	0.027	0.027	0.003	0.010	0.027	
28	27	26	25	24	23	22	
				0.031	0.086	0.138	

Figure 7A. Positional Correlation using Character Set A

CRTI

OVERALL PERFORMANCE

1 0.027	2 0.121	3 0.083	4 0.111	5 0.104	6 0.069	7 0.138
------------	------------	------------	------------	------------	------------	------------

14 0.069	13 0.111	12 0.111	11 0.076	10 0.083	9 0.093	8 0.125
-------------	-------------	-------------	-------------	-------------	------------	------------

15 0.093	16 0.048	17 0.055	18	19	20	21
-------------	-------------	-------------	----	----	----	----

28	27	26	25	24	23	22
----	----	----	----	----	----	----

Figure 7B. Positional Correlation using Character Set B

Normalized Percentage Error (Figure 8A and Figure 8B)

These Figures show the normalized percentage error for each character displayed, i.e. total number of errors divided by the product of the total number of subjects and the frequency of occurrence of the character.

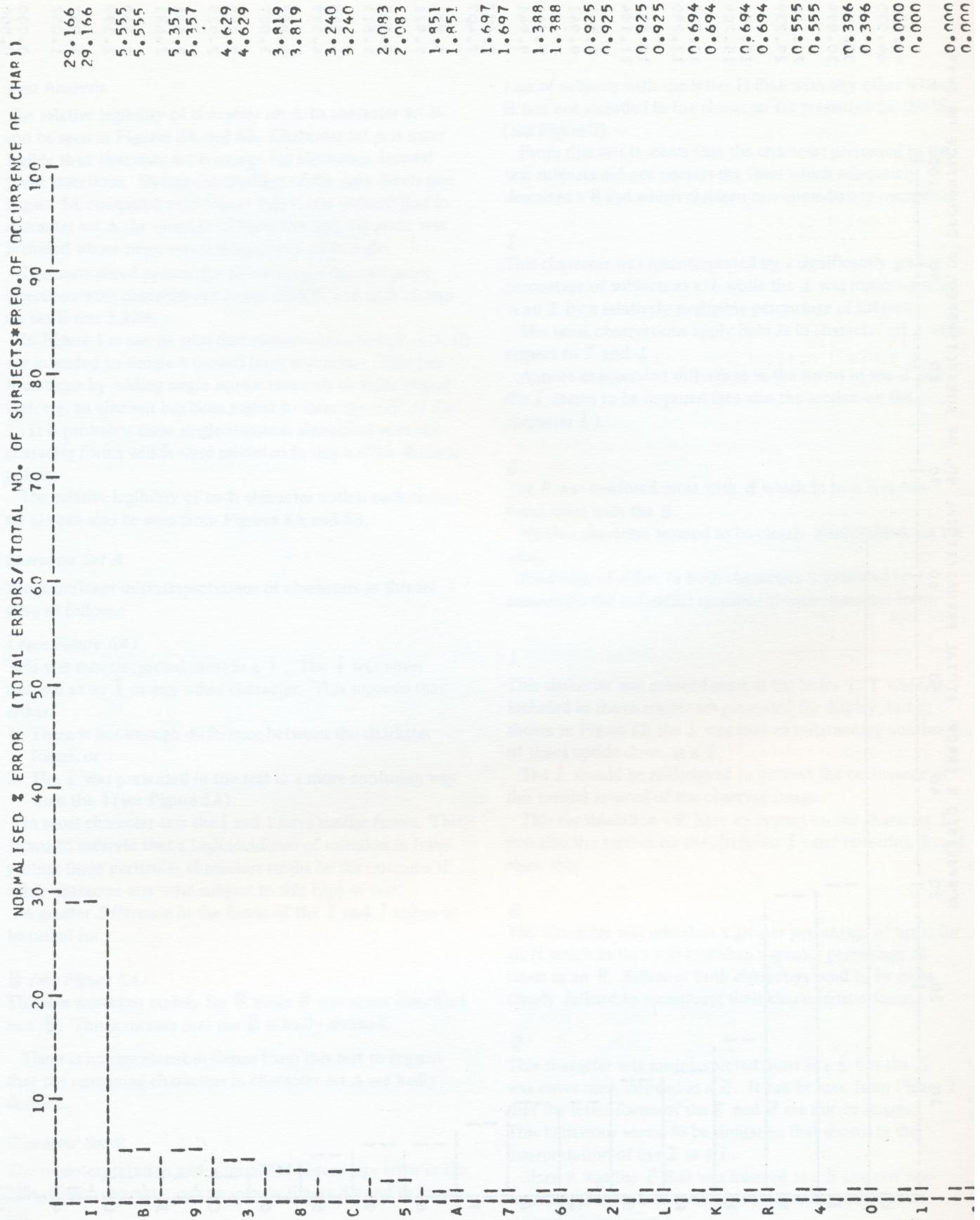


Figure 8A. Normalized Percentage Error using Character Set A

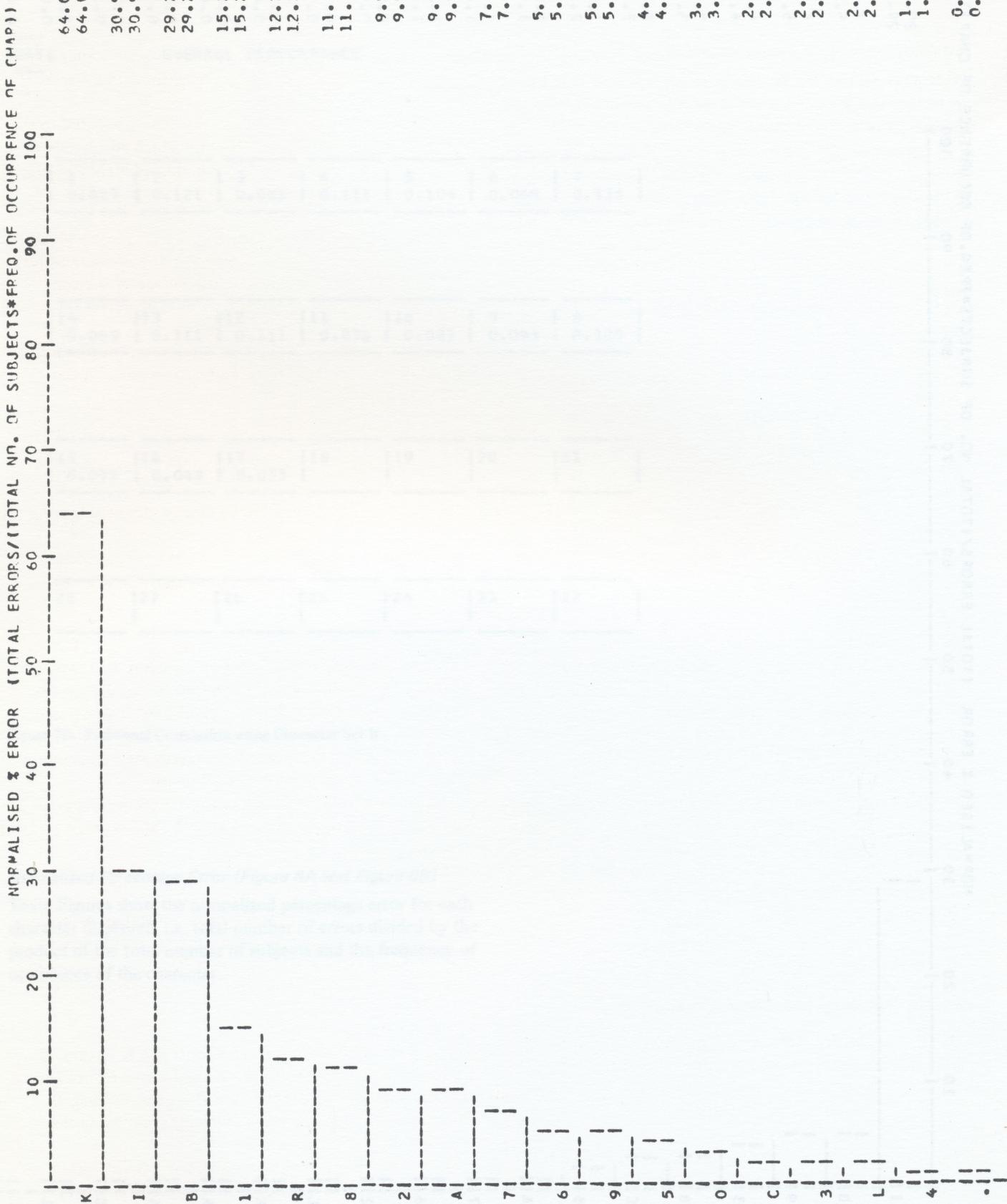


Figure 8B. Normalized Percentage Error using Character Set B

Test Analysis

The relative legibility of character set A to character set B can be seen in Figures 8A and 8B. Character set A is more legible than character set B except for erroneous decimal point insertions. During the marking of the data sheets (see Figure 5A compared with Figure 5B) it was noticed that in character set A the number of times the decimal point was included where none was displayed was quite high.

The normalized percentage of erroneous decimal point insertions with character set A was 15.97% and with character set B was 3.92%.

In Figure 1 it can be seen that certain characters (2, 3, 5, C) are intended to simulate curved form characters. This has been done by adding single square elements to these characters, e.g. an element has been added to form the 'tail' of the 5. It is probably these single elements associated with the character forms which were mistaken in this test for decimal points.

The relative legibility of each character within each character set can also be seen from Figures 8A and 8B.

Character Set A

The significant misinterpretations of characters in this set were as follows:

I (see Figure 6A)

This was misinterpreted most as a 1. The 1 was never misread as an I or any other character. This suggests that either

1. There is not enough difference between the character forms, or
2. The I was presented in the test in a more confusing way than the 1 (see Figure 5A).

In most character sets the I and 1 have similar forms. This seems to indicate that a high incidence of mistakes in interpreting these particular characters might be the outcome if other character sets were subject to this type of test.

A greater difference in the forms of the I and 1 seems to be called for.

B (see Figure 6A)

This was mistaken mainly for 8 while 8 was never identified as a B. This indicates that the B is badly defined.

There is no significant evidence from this test to suggest that the remaining characters in character set A are badly defined.

Character Set B

The misinterpretation and normalized percentage error in the case of each character can be seen in Figure 8B and in Figure 6B.

H

This character was confused by a significantly greater per-

tage of subjects with the letter H than with any other letter. H was not included in the character set presented for the test (see Figure 2).

From this test it seems that the character presented to the test subjects did not possess the form which adequately describes a H and which children can immediately recognize.

I

This character was misinterpreted by a significantly greater percentage of subjects as a 1 while the 1 was misinterpreted as an I by a relatively negligible percentage of subjects.

The same observations apply here as in character set A with respect to I and 1.

A more exaggerated difference in the forms of the 1 and the I seems to be required (see also the section on the character 1).

B

The B was confused most with 8 which in turn was confused most with the B.

Neither character seemed to be clearly identifiable from the other.

Re-design of either or both characters is indicated to accentuate the individual qualities of each character form.

1

This character was misread most as the letter T. T was not included in the character set presented for display, but as shown in Figure 6B the 1 was read an outstanding number of times upside-down as a T.

The 1 should be re-designed to prevent the occurrence of this mental reversal of the observed image.

This consideration will have an impact on the character I (see also the section on the character I) and re-testing should show this.

R

This character was mistaken a greater percentage of times for an H which in turn was mistaken a greater percentage of times as an R. Either or both characters need to be more clearly defined to accentuate their characteristic forms.

Z

This character was misinterpreted most as a 5 but the 5 was never once misread as a Z. It can be seen from Figure 2 that the letter forms of the 5 and Z are mirror images. This behaviour seems to be similar to that shown in the interpretation of the I as a T.

Since it was the Z that was misread as a 5 and not vice-versa the Z should be re-designed to prevent this mental reversal of the image.

L

This character was misinterpreted most as an L whereas the

L was only once misread as a **7**. From the complete set of test characters (see Figure 2) it can be seen that **7** and **L** are nearly mirror images. Again this is the reversal effect described above.

Since it is the **7** that is misinterpreted and not the **L**, the **7** should be re-designed to prevent this reversal effect.

6

This character was mistaken most for a **S** while a **S** was mistaken only once for a **G** (see Figure 6B).

A modification to the form of the **S** is indicated.

7

This character was mistaken most for a **7**, the **7** being mistaken for a **7** a negligible number of times (see Figure 6B).

The **7** was misinterpreted most as an **L** (see above) and re-design to prevent the mirror image effect is suggested. A change in this respect will obviously affect the interaction of the **7** and **7** forms. Re-testing will show the effects of a re-designed **7** on the unchanged **7** and **L** characters.

The incidence of mistakes with respect to the remaining characters in character set B was low and did not provide any significant evidence upon which to re-design the remaining characters.

Seat Position and Legibility (see Figures 7A and 7B)

There is no indication, under the conditions of this test, to show any correlation between legibility and seating position.

It is interesting to note how a test of this nature can be used to investigate the effect of seating position on legibility. In this case, the test was conducted in a room with a large amount of furniture and equipment, and the seating positions were not necessarily the best for reading. However, the results do suggest that there is no significant difference in legibility between the different seating positions. This is particularly true for the first two rows of seats, where the legibility scores are very similar. The last row of seats, however, shows a slight decrease in legibility compared to the other rows. This may be due to the fact that the last row of seats is further from the projector than the other rows, and therefore the image appears smaller and less sharp. It is also possible that the last row of seats is less comfortable than the other rows, which may affect the reader's ability to concentrate and read accurately.

It is also interesting to note that the legibility scores for the first two rows of seats are very similar, even though the seating positions are quite different. This suggests that the seating position has a relatively small effect on legibility, at least in this particular test. However, it is important to remember that this test was conducted in a room with a lot of furniture and equipment, which may have affected the legibility scores. It would be interesting to conduct a similar test in a more controlled environment, such as a laboratory, to see if the results are similar.

In conclusion, this test provides some evidence that seating position may have a small effect on legibility, but this effect is not very strong. It is also important to remember that this test was conducted in a room with a lot of furniture and equipment, which may have affected the results.

Legibility Test 2

INTRODUCTION

After legibility test 1 the two character sets were re-designed taking into consideration the results of the test.

Character set A (shown in Figure 9) and character set B (shown in Figure 10) were then used for the second legibility test.

Test Subjects

The subjects used for the test were a group of boys and girls from a comprehensive school, aged from 11 to 17 years.

Test Environment

The test environment was a school classroom, considered typical of most school classroom situations, i.e. there was no special equipment or seating arrangements for using educational television.

The seating arrangements and position of the TV screen is shown in Figure 4. This arrangement is based, as far as the prevailing classroom conditions would allow, on the recommendations contained in the report by Neal¹.

The test was carried out simultaneously in five classrooms using a closed circuit TV system.

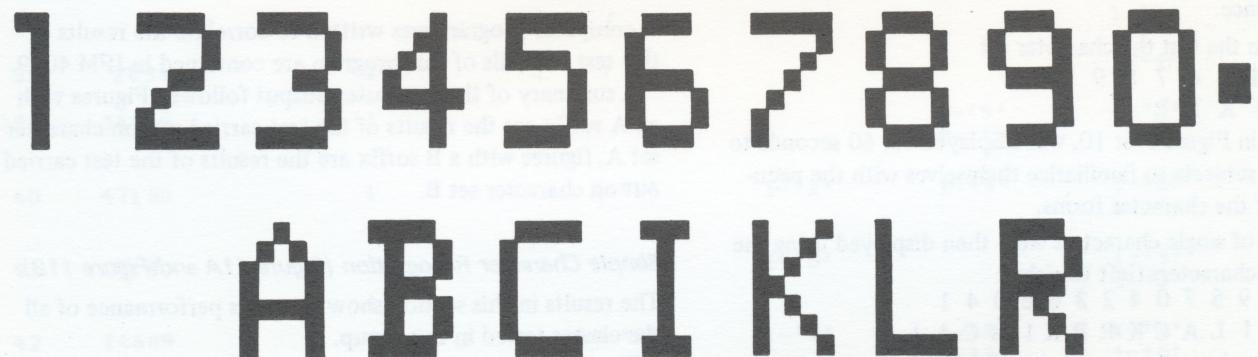


Figure 9. Character Set A used in Legibility Test 2



Figure 10. Character Set B used in Legibility Test 2

Test Objectives

The objectives of the legibility test were:

1. To test the relative legibility of character sets A and B.
2. To test the relative legibility of each character within each set.
3. To see if there was any correlation between legibility and seat position.

Test Procedures

The following procedures were used when carrying out the tests:

1. The character sets A and B were shown separately.
2. Only one character set was shown to each group of subjects.
3. No group was shown both character sets.
4. No group was tested more than once.
5. The number of subjects per group varied.
6. Each seat position was numbered and subjects were seated from position 1, i.e. nearest TV upwards (see Figure 4).
7. Each subject was given a form at the time of testing upon which to record the seat position occupied and the characters viewed.

The Legibility Tests

The tests for both character sets were identical in content and sequence.

To begin the test the character set

1 2 3 4 5 6 7 8 9 0 .

A B C I K L R

as shown in Figure 9 or 10, was displayed for 60 seconds to allow the subjects to familiarize themselves with the peculiarities of the character forms.

A series of single characters were then displayed using the following characters (left to right):

6 1 3 5 9 8 7 0 4 2 3 6 8 0 4 1

5 2 7 9 I L A C K R B K I B C A L R

Each single character was displayed for $\frac{1}{2}$ second, with a pause of 10 seconds between each character.

A series of character strings were displayed using the following characters (top to bottom):

801.7

769.3

8765

2039

34689

47180

C7180

14689

L01.7

B69.3

A765

Each character string was displayed for 1 second, with a pause of 10 seconds between each character string.

The simulation of the test display was effected by showing a video tape recording of drawn characters on a 23-in. domestic TV set.

It was noticed in test 1 that the children's attention was apt to wander during the 10-second pause between pictures so in test 2 a 'bleep' was added to the video tape 2 seconds before a picture was shown in an attempt to overcome this.

In test 1 it was difficult to tell from the completed forms how a child normally wrote the displayed characters, in particular an I and a 1, therefore, it was difficult to mark the completed test forms in this respect.

To obtain a more accurate assessment of the children's interpretations of the characters and of the I's and 1's they were asked during the first stage of the display sequence to write the character set down in a space provided on the test form.

Test Results

A computer program was written to correlate the results of this test. Details of this program are contained in IFM 4029.

A summary of the computer output follows. Figures with an A suffix are the results of the test carried out on character set A, figures with a B suffix are the results of the test carried out on character set B.

Simple Character Recognition (Figure 11A and Figure 11B)

The results in this section show the mass performance of all the classes tested in this group.

The patterns and statement numbers (ST NO) represent the displayed character string and its presentation number respectively. An entry under DEC. PT. INSERTIONS indicates the total number of times decimal points were inserted erroneously.

Entries in one of the five character positions show the total frequency of misinterpreted characters, e.g., 1-'0' means that the character 3 was misinterpreted once as being a zero.

* Internal File Memorandum (Hursley Laboratories)

STNO	PATTERN	DEC.PT.INSERTIONS	CHARACTER POSITIONS				
			1	2	3	4	5
2	1	0	/	/	/	/	2-17'
4	5	0	/	/	/	/	1-13'
5	9	0	/	/	/	/	1-13'
12	6	0	/	/	/	/	1-15'
16	1	0	/	/	/	/	1-14' 1-11'
19	7	0	/	/	/	/	1-10'
21	I	0	/	/	/	/	1-11'
23	A	0	/	/	/	/	1-1H'
29	I	0	/	/	/	/	1-11'
32	A	0	/	/	/	/	1-1H'
34	R	0	/	/	/	/	1-1P'
35	801.7	0	1-19'				
36	769.3	0	1-12'	1-15'			1-16' 1-18'
37	8765	3	/	1-13'	1-13'	1-18'	1-13'
			/			1-15'	
			/			1-19'	
38	2039	2	/			1-19'	3-15'
39	34689	1			1-15'	1-11'	1-13'
					2-18'		
40	47180	1	1-11'	1-12'	1-19'	1-16'	1-19' 1-14'
41	C7180	1	1-16'	1-10'		1-13'	1-12'
42	I4689	0	28-1'	1-18'	1-18'	1-19'	1-17'
					2-15'	1-10'	
					1-11'		
					1-13'		
43	L01.7	0	1-14'				
			1-11'				
44	B69.3	1	1-18'	1-15'	1-13'		2-12' 1-10' 1-1C' 1-15' 1-17' 1-18'
			1-12'	2-13'			
45	A765	3	/	3-18'			4-19' 2-13'
			/				

Figure 11A. Results of Simple Character Recognition using Character Set A

STNO	PATTERN	DEC.PT.	INSERTIONS	CHARACTER POSITIONS				
				1	2	3	4	5
1	6	0		/	/	/	/	1-'E' 1-'5'
2	1	0		/	/	/	/	1-'I' 1-'7'
3	3	0		/	/	/	/	1-'B'
4	5	0		/	/	/	/	4-'S'
5	9	0		/	/	/	/	2-'B'
6	8	0		/	/	/	/	1-'6' 1-'0'
8	0	0		/	/	/	/	1-'3'
10	2	0		/	/	/	/	1-'8'
12	6	0		/	/	/	/	1-'E' 1-'5'
				/	/	/	/	1-'5'
13	8	0		/	/	/	/	1-'C'
14	0	0		/	/	/	/	4-'S'
17	5	0		/	/	/	/	1-'1'
21	I	0		/	/	/	/	1-'4'
22	L	0		/	/	/	/	5-'R'
23	A	0		/	/	/	/	1-'K'
24	C	0		/	/	/	/	1-'E'
25	K	0		/	/	/	/	2-'H' 1-'M'
				/	/	/	/	1-'F'
26	R	0		/	/	/	/	2-'A'
27	B	0		/	/	/	/	1-'D'
28	K	0		/	/	/	/	2-'H' 1-'R'
30	B	0		/	/	/	/	1-'R' 1-'O' 1-'H'
				/	/	/	/	1-'E'
31	C	0		/	/	/	/	7-'R'
32	A	0		/	/	/	/	

Figure 11B (Part 1). Results of Simple Character Recognition using Character Set B

STNO	PATTERN	DEC.PT.	INSERTIONS	CHARACTER POSITIONS				
				1	2	3	4	5
34	R	0		/ /	/ /	/ /	/ /	1-'7' 1-'A'
35	801.7	0		2-'A' 4-'B' 1-'6'				2-'2' 1-'1' 1-'K' 1-'R' 1-'8'
36	769.3	1		1-'4' 1-'A' 1-'9'	2-'5'			1-'0' 2-'8'
37	8765	5		/ /	2-'5'			1-'3' 1-'9'
38	2039	2		/		1-'5'	1-'5'	1-'7'
39	34689	2			1-'6'	2-'5' 1-'8'	3-'5' 2-'4'	1-'5' 1-'7'
40	47180	0				1-'5'	1-'9'	1-'1' 1-'9'
41	C7180	4		1-'0'			1-'6' 2-'4' 1-'1'	1-'6'
42	I4689	2		21-'1' 1-'7' 2-'T'		1-'5' 1-'8'	1-'4'	2-'0' 1-'1' 2-'7'
43	L01.7	0		1-'4'		3-'4'		2-'1' 4-'9'
44	B69.3	0		17-'8' 1-'P' 2-'4' 1-'R'	1-'7' 1-'5'	3-'7' 2-'4' 1-'6'		2-'7' 2-'5' 1-'8' 1-'8'
45	A765	1		/ /	6-'R' 1-'B' 1-'8'	2-'1' 1-'3'		3-'3'

Figure 11B (Part 2). Results of Simple Character Recognition using Character Set B

Incidence of Mistakes (Figure 12A and Figure 12B)

This section shows the total incidence of mistakes as a function of a particular character in the adopted character set.

The frequency of occurrence indicates the total number of times the character was displayed on the TV screen.

The normalized percentage is derived from the formula

$$\frac{\text{total mistakes}}{\text{frequency of occurrence} \times \text{total no. of subjects}}$$

The total number of subjects tested using character set A = 118

The total number of subjects tested using character set B = 141

CHARACTER	FREQ.OF OCC	TOTAL MISTAKES	NORM %	INTERPRETATIONS
1	6	5	0.706	2-'7' 1-'4' 1-'1' 1-'9'
3	6	10	1.412	2-'2' 1-'9' 1-'0' 1-'C' 1-'5' 1-'7' 2-'8' 1-'6'
4	5	2	0.338	1-'8' 1-'1'
5	4	8	1.694	4-'3' 4-'9'
6	8	16	1.694	4-'8' 7-'5' 1-'1' 3-'3' 1-'9'
7	9	5	0.470	2-'2' 1-'0' 1-'3' 1-'C'
8	8	9	0.953	2-'3' 1-'6' 3-'9' 1-'1' 2-'0'
9	7	7	0.847	3-'3' 1-'7' 3-'5'
0	7	3	0.363	1-'9' 1-'2' 1-'4'
A	3	5	1.412	3-'8' 2-'H'
B	3	2	0.564	1-'8' 1-'2'
C	3	1	0.282	1-'6'
I	3	30	8.474	30-'1'
L	3	2	0.564	1-'4' 1-'1'
R	2	1	0.423	1-'P'

Figure 12A. Incidence of Mistakes using Character Set A

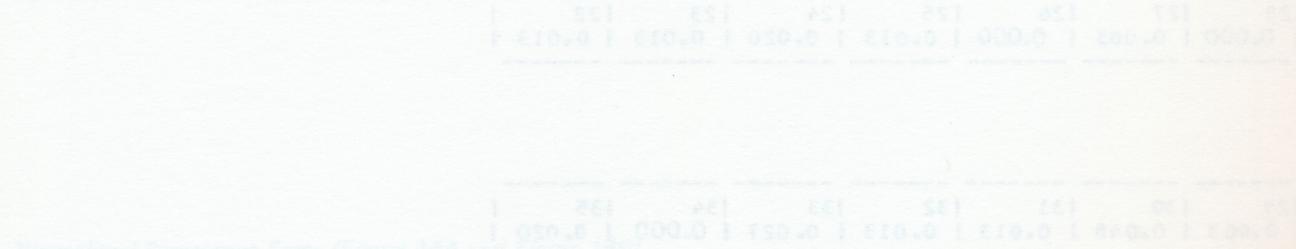
CHARACTER	FREQ.OF OCC	TOTAL MISTAKES	NORM %	INTERPRETATIONS
1	6	6	0.709	3-4 1-1 1-5 1-7
2	3	1	0.236	1-3
3	6	11	1.300	2-7 1-0 3-5 2-8 3-8
4	5	1	0.141	1-6
5	4	13	2.304	4-3 8-S 1-9
6	8	14	1.241	1-7 8-5 3-8 2-E
7	9	18	1.418	5-1 2-2 1-4 1-A 5-9 1-K 1-R 1-8 1-3
8	8	23	2.039	7-B 5-5 2-6 2-A 5-4 1-1 1-9
9	7	15	1.519	2-0 7-7 1-A 2-4 1-1 1-6 1-5
0	7	7	0.709	1-1 2-6 1-5 1-D 1-C 1-9

Figure 12B (Part 1). Incidence of Mistakes using Character Set B

CHARACTER	FREQ. OF OCC	TOTAL MISTAKES	NORM %	INTERPRETATIONS
A	3	21	4.964	10-'R' 1-'B' 1-'K' 1-'S'
B	3	27	6.382	17-'S' 1-'P' 2-'4' 2-'A' 2-'R' 1-'O' 1-'H' 1-'D'
C	3	3	0.709	2-'E' 1-'O'
I	3	25	5.910	22-'1' 1-'7' 2-'T'
K	2	6	2.127	4-'H' 1-'R' 1-'M'
L	3	2	0.472	2-'4'
R	2	3	1.063	1-'7' 1-'F' 1-'A'

Figure 12B (Part 2). Incidence of Mistakes using Character Set B

Figure 12B. Fractional Deviations of Characters



Normalized Percentage Error (Figure 12A and 12B)

These Scores show the normalized percentage error each character displayed, i.e., the number of errors divided by the product of the total number of subjects and the frequency of occurrence of the character.

A red colored character should receive a high score.

Positional Correlation (Figure 13A and Figure 13B)

The results given in the Figures show any correlation between the position of the pupil in the classroom and the legibility of the characters in the character set.

The entries in each seat position represent the total number of times the seat was occupied divided by the product of the number of times the seat was occupied and the frequency of occurrences of the character.

CRT

OVERALL PERFORMANCE

1	2	3	4	5	6	7
0.020	0.010	0.010	0.003	0.003	0.003	0.010

14	13	12	11	10	9	8
0.003	0.013	0.003	0.041	0.010	0.027	0.003

15	16	17	18	19	20	21
0.027	0.000	0.013	0.013	0.000	0.013	0.027

28	27	26	25	24	23	22
0.000	0.003	0.000	0.013	0.020	0.013	0.013

29	30	31	32	33	34	35
0.003	0.048	0.013	0.013	0.027	0.000	0.020

Figure 13A. Positional Correlation using Character Set A

ICRT

OVERALL PERFORMANCE

1	2	3	4	5	6	7	
0.000	0.003	0.003	0.031	0.003	0.003	0.013	

14	13	12	11	10	9	8	
0.020	0.055	0.013	0.038	0.013	0.069	0.003	

15	16	17	18	19	20	21	
0.038	0.013	0.000	0.038	0.010	0.000	0.013	

28	27	26	25	24	23	22	
0.010	0.069	0.003	0.003	0.031	0.013	0.020	

29	30	31	32	33	34	35	
0.000	0.000	0.000	0.013	0.013			

Figure 13B. Positional Correlation using Character Set B

Normalized Percentage Error (Figure 14A and Figure 14B)

These figures show the normalized percentage error each character displayed, i.e. total number of errors divided by the product of the total number of subjects and the frequency of occurrence of the character.

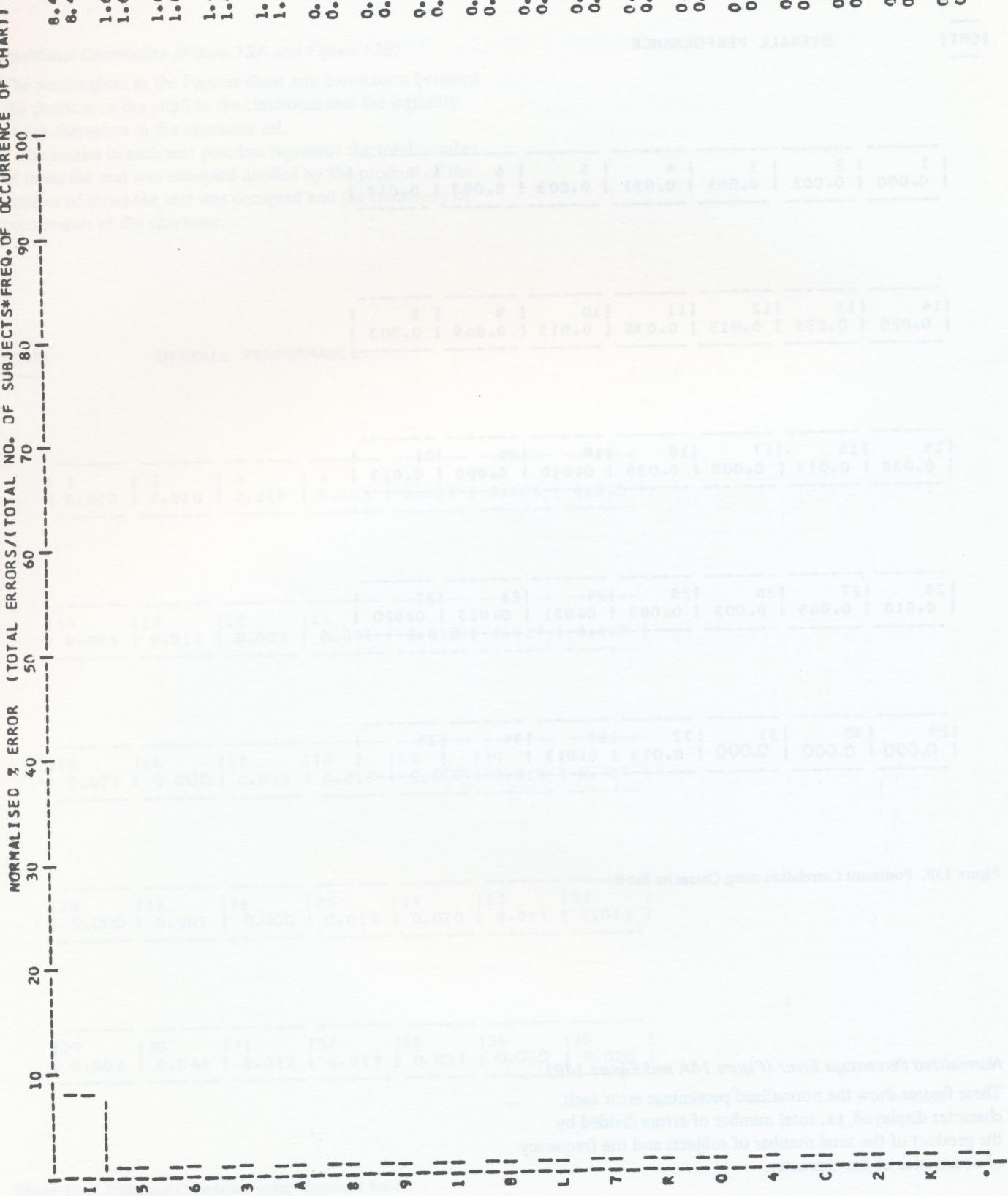


Figure 14A. Normalized Percentage Error using Character Set A

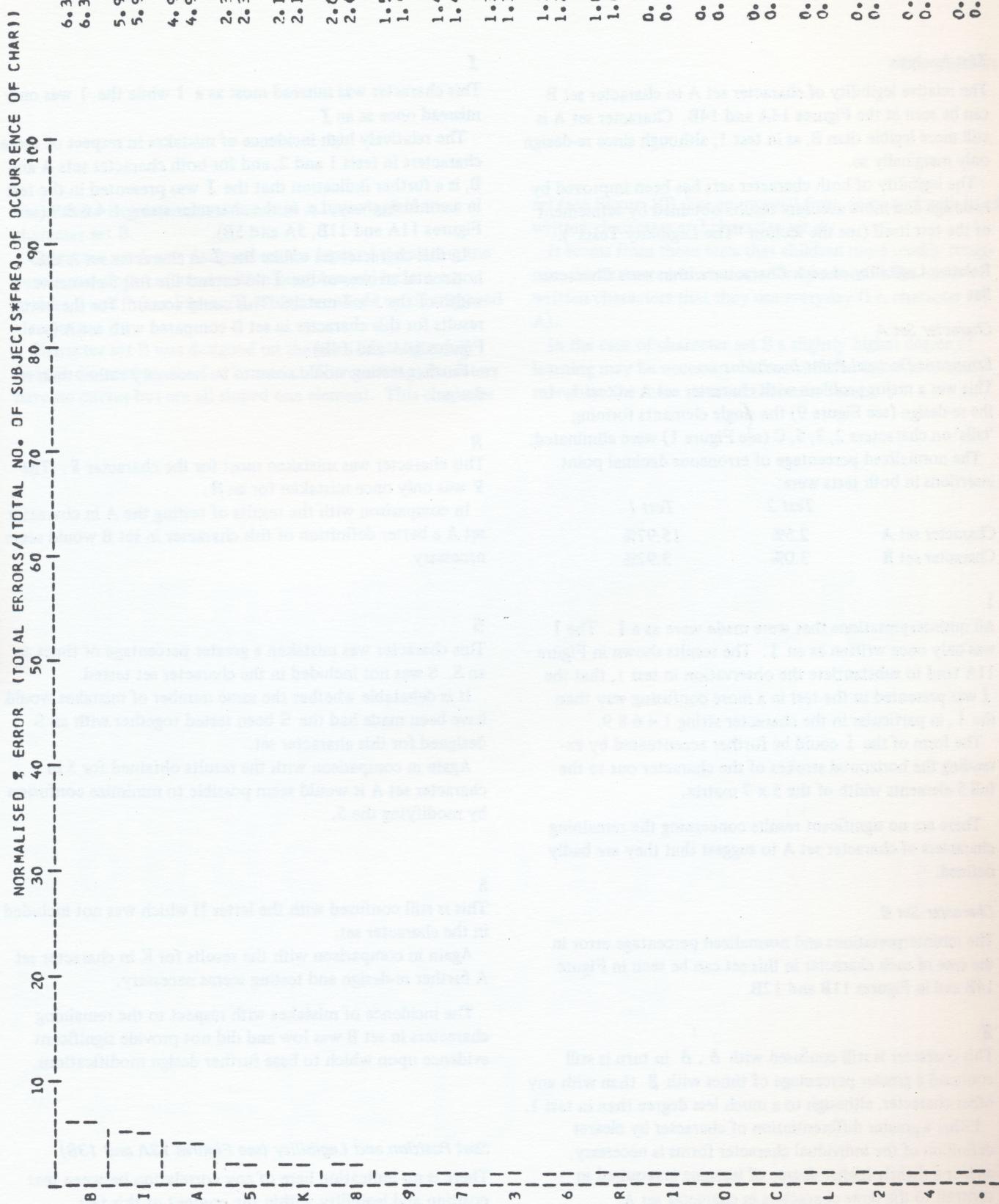


Figure 14B. Normalized Percentage Error using Character Set B

Test Analysis

The relative legibility of character set A to character set B can be seen in the Figures 14A and 14B. Character set A is still more legible than B, as in test 1, although since re-design only marginally so.

The legibility of both character sets has been improved by re-design and more accurate results obtained by refinement of the test itself (see the section "The Legibility Tests").

Relative Legibility of each Character within each Character Set

Character Set A

Erroneous Decimal Point Insertions

This was a major problem with character set A in test 1. In the re-design (see Figure 9) the single elements forming 'tails' on characters 2, 3, 5, C (see Figure 1) were eliminated.

The normalized percentage of erroneous decimal point insertions in both tests were:

	Test 2	Test 1
Character set A	2.5%	15.97%
Character set B	3.0%	3.92%

I

All misinterpretations that were made were as a 1. The 1 was only once written as an I. The results shown in Figure 11A tend to substantiate the observation in test 1, that the I was presented in the test in a more confusing way than the 1, in particular in the character string 1 4 6 8 9.

The form of the I could be further accentuated by extending the horizontal strokes of the character out to the full 5 elements width of the 5 x 7 matrix.

There are no significant results concerning the remaining characters of character set A to suggest that they are badly defined.

Character Set B

The misinterpretations and normalized percentage error in the case of each character in this set can be seen in Figure 14B and in Figures 11B and 12B.

H

This character is still confused with B. B in turn is still confused a greater percentage of times with H than with any other character, although to a much less degree than in test 1.

Either a greater differentiation of character by clearer definition of the individual character forms is necessary, and/or a slightly higher degree of learning is required in contrast to the same characters in character set A.

I

This character was misread most as a 1 while the 1 was only misread once as an I.

The relatively high incidence of mistakes in respect of these characters in tests 1 and 2, and for both character sets A and B, is a further indication that the I was presented in the test in a confusing way, i.e. in the character string 1 4 6 8 9 (see Figures 11A and 11B, 5A and 5B).

In this character set unlike the I in character set A the horizontal strokes of the I do extend the full 5 elements width of the 5 x 7 matrix. This could account for the better results for this character in set B compared with set A (see Figures 14A and 14B).

Further testing would seem to be necessary rather than re-design.

H

This character was mistaken most for the character H. The H was only once mistaken for an H.

In comparison with the results of testing the A in character set A a better definition of this character in set B would seem necessary.

S

This character was mistaken a greater percentage of times as an S. S was not included in the character set tested.

It is debatable whether the same number of mistakes would have been made had the S been tested together with an S designed for this character set.

Again in comparison with the results obtained for S in character set A it would seem possible to minimize confusion by modifying the S.

K

This is still confused with the letter H which was not included in the character set.

Again in comparison with the results for K in character set A further re-design and testing seems necessary.

The incidence of mistakes with respect to the remaining characters in set B was low and did not provide significant evidence upon which to base further design modifications.

Seat Position and Legibility (see Figures 13A and 13B)

There is no indication here of any correlation between seat position and legibility within the context of this test.

Conclusion

From these two tests character set A is more legible than character set B.

Character set A was designed on the basis of simulating the curves and slopes of handwritten numbers and letters, e.g. such as 2 and 7 (see Figure 9), which are made up of staggered elements.

Character set B was designed on the basis of straight full lines as dictated by the 5 x 7 matrix. The resulting characters have no curves but are all sloped one element. This character

set (see Figure 10), has an unusual form compared with handwritten characters and character set A.

It seems from these tests that children more readily recognize the characters that most closely resemble the handwritten characters that they use everyday (i.e. character set A).

In the case of character set B a slightly higher degree of learning may be necessary before children are able to easily recognize the more unusual character forms.

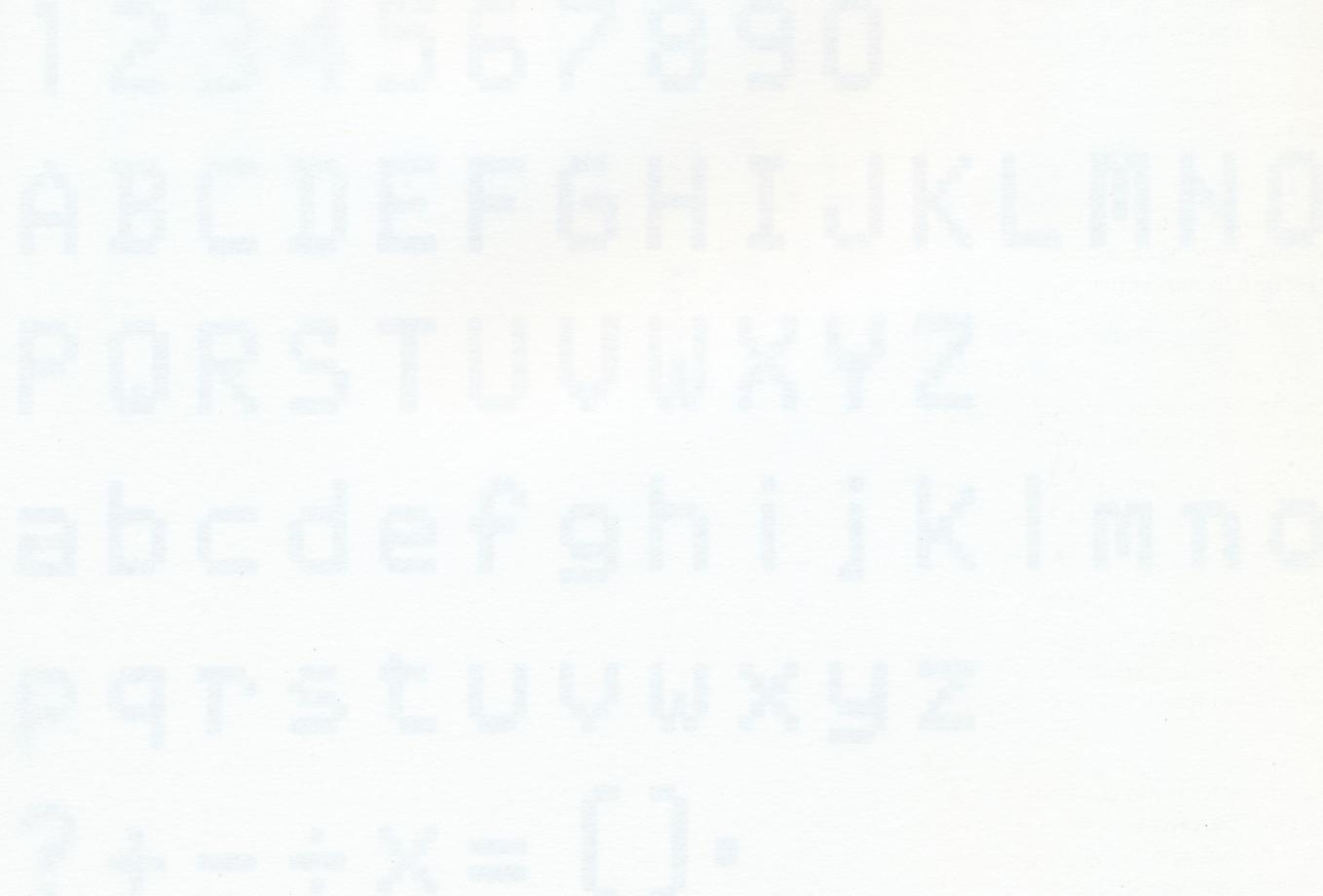


Figure 10. Design Comparison of the Characters Set A.

Reference

1. Neal, H.S., Legibility Requirements for Educational Television, TR.16.161, IBM Los Gatos.

Figures 15 and 16 illustrate design concepts for character sets A and B illustrating complete numeric and alphabetic sets. These have not been subject to the legibility tests.

1 2 3 4 5 6 7 8 9 0
A B C D E F G H I J K L M N O
P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o
P Q R S T U V W X Y Z
? + - ÷ × = [] .

Figure 15. Design Concept for Character Set A

1 2 3 4 5 6 7 8 9 0
A B C D E F G H I J K L M N O
P Q R S T U U Ш К Y I
a b c d e f g h i j k l m n o
P Q R S T U U Ш К Y I
? + - ÷ = [] .

Figure 16. Design Concept for Character Set B