EFFECT OF FONT AND MEDIUM ON RECOGNITION/CONFUSION

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ABSTRACT

Systematic differences in recognition/confusion due to font variation is estimated by using confusion matrices of the full 26 capital letters of the English alphabet in 5 x 7 dot matrix font and "Keepsake" conventional stroke font. Average correct recognition was controlled to 50% by limiting brightness and duration of tachistoscopic displays for each font to individually determined levels for each of the four subjects. Each stimulus symbol was presented 45 times to each subject, resulting in 180 trials per letter per font.

By comparing the obtained data to that reported by Townsend(1971), Craig(1979) and Gilmore et al.(1979), estimates of the differences in recognition/confusion attributable to medium, font and subject differences were isolated. This comparison reveals a substantial difference in recognition/confusion processes when the observer sees the display on a video screen versus seeing it projected on a white screen.

INTRODUCTION

Gupta and Geyer(1980), discussed the differences between confusion matrices obtained by Townsend(1971a,b) using tachistoscopic presentation of IBM Executive Diretrix capital letters and by Gilmore et al(1979) using video presentation of 5 x 7 dot matrix capital letters. They suggested that the differences, "if reliable and stable", would be interesting theoretically and practically. Theoretically, the comparisons might help understand the relationship between features and recognition. Practically, they might help modify details of the dot matrix font in order to improve recognition using video presentation.

In a later study, Geyer and Gupta(1981) used a selected set of nine letters as the stimulus set. Using tachistoscopic presentation, response data were collected for three confusion matrices, the same 5 x 7 dot font used by Gilmore et al(1979), a conventional stroke font, and a "Filled" font obtained by blacking in the appropriate spaces between dots. The presentation duration was the same for all stimuli in all three fonts, leading to average correct recognition of 0.28(dot), 0.69 (stroke). While these results supported the expected differences in performance attributable to font, the differences in average correct recognition made interpretation of the results more difficult.

In this study the procedure for determining the confusion matrices for the two fonts used was similar to that of the Geyer and Gupta(1981) study except that 1) it was conducted with the full twenty-six capital letter alphabet, 2) only dot and stroke fonts were used, and 3) most importantly, presentation duration was computer controlled for the separate fonts, in order to achieve 50% average recognition, for the conventional stroke and dot matrix fonts individually.

Since the comparison of confusion matrices can involve differences attributable to at least three independent variables: 1) font, 2) medium, and 3) subjects, it could be illuminating to develop a procedure which attempts to parcel out the components of variance attributable to these causes.

To attempt such an analytic development, it was planned to make pairwise comparisons of sum square differences, summed across all 26 X 26 cells, for all combinations of confusion matrices referred to previously. The hope was to find some apparently meaningful pattern of attribution of individual sum square comparisons to independent variables. Gupta and Geyer(1980) presented a preliminary attempt at this sort of analysis, but they lacked data for important comparisons data supplied by this study.

METHODOLOGY

Subjects

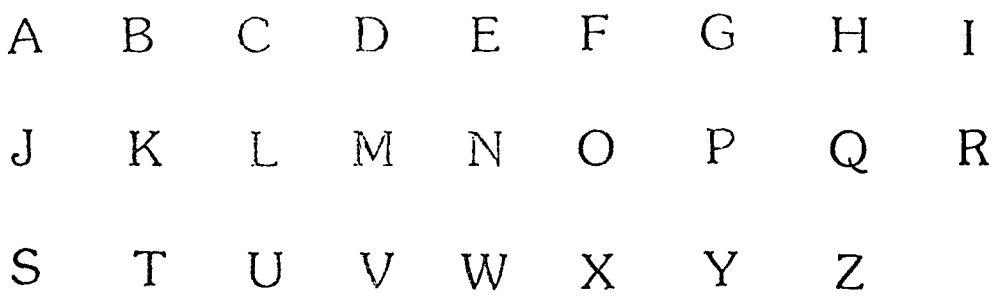
Four male students volunteered as subjects. All four subjects had normal vision, without correction, at the viewing distance described.

Apparatus and Stimuli

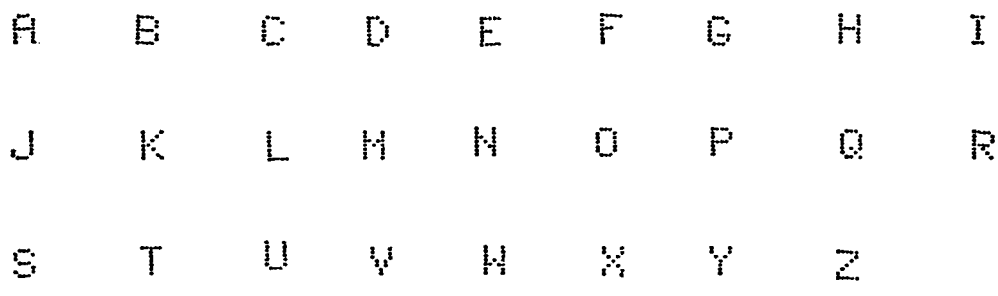
The presentation device was a slide projector techistoscope. There were three sets of full capital English alphabet letters in each of the two fonts used (a 5 X 7 dot matrix font and "Keepsake", a conventional font (stroke)), and six catch trial slides (Figure 1), comprising 162 slides. Slides were assembled in random order in two eighty position carousel slide trays (actually 81 positions since the procedure also included the "zero position").

Stimuli were presented on a white background at a viewing distance of eight feet. The vertical visual angle subtended was approximately 1.0 degree. A fixation dot was permanently mounted on the background screen, centered just below all stimuli. All letters were identical in height. A microcomputer was used to set the shutter on and off for each slide presentation, thereby allowing display duration to be separately controlled from display to display. This capability was used to adjust presentation for the two fonts, individually, but all displays of one font were at the same

Figure 1. Fonts Used In Study.



Stroke "Keepsake" Font.



Dot Font.

duration. A neutral density filter was attached to the shutter in order to decrease luminous intensity.

Procedure

There was a session to introduce the subjects to the procedure to be followed and to begin to calibrate display energy required for 50% correct performance. A second session was conducted in order to complete the adjustment of display intensity and duration to achieve approximately fifty percent average correct recognition for each font, individually. Based on these calibration sessions, presentation time was set for each of the four subjects.

In the three data collection sessions, each subject was presented each stimulus letter in each font 45 times; resulting in 180 trials per letter per font. Each data session required approximately 70 minutes, including an initial ten minute period for adaptation to the dimly lit experimental room, ten 81 trial cycles at approximately five minutes each, and a ten minute break after the fifth cycle.

Each cycle of eighty-one slides started from a randomly selected slide carousel position, and continued for one full revolution. The subject initiated each cycle when ready. There was a three second delay between trials within a cycle.

RESULTS

Tables 1 and 2 present the composite confusion matrices obtained for the two different fonts. The average correct recognition along the main diagonal for the dot font was 50.6%, and 50.8% for the stroke. The ratio of display time for stroke to display time for dot was .625. Average correct recognition was similar, but correct recognition of individual letters and relative confusability of letter pairs differed from one font to the other. These differences contributed to the overall SS difference between the matrices reported in Table 3.

ANALYSIS

The dot fonts used in this study were identical to that used by Gilmore et al.(1979). By considering data from this study, Gilmore et al. and Townsend(1971 a and b), it is possible to compare confusion matrices differing in the following combinations of the three sources of variance previously discussed:

Only subjects different - Townsend - see line 1, Table 4.

Only font different - this study - see line 2, Table 4.

Subjects and font different - this study vs. Townsend - see line 4, Table 4.

Subjects and medium different - this study vs. Gilmore et al. - see line 5, Table 4.

Subjects, font and medium different - Townsend vs Gilmore et al. - see line 7, Table 4.

The comparisons to Townsend(1971 a and b) involve three independently obtained matrices, providing estimates based on the average of three values. Other comparisons are between individual matrices, as reported. Table 4 presents these data.

DISCUSSION

The SSE column in Table 4 shows sum square differences obtained by direct computation from empirical matrices differing in the indicated combinations of font, subject and presentation medium.

The value column shows various predictable estimates based upon the assumption that the variance introduced by the three sources is independently additive. The sum square values obtained for both direct and indirect computation, for the cases possible (lines 4, 5 and 7), seem reasonable, particularly in view of the wide separation in time and place of the sets of original data. Perhaps the most interesting facet of this entire analysis, however, is the estimated value of sum square variance attributable to the difference in tachistoscopic versus video presentation. The estimated range is from 1.05 to 1.5, which is more than the sum square variance due either to subjects alone or to the rather dramatically different fonts depicted in Figure 1.

Differences attributed to individuals and font are well accepted in the literature. Except for a speculative comment by Geyer and Gupta(1981), differences due to medium have not been discussed previously, so far as the investigators are aware. With all the attention being given to visual performance at video work stations, the somewhat counter-intuitive aspects of this analyses seem to invite further efforts at understanding. Just what aspect(s) of the visual system may be involved is not clear to us, but the analysis may stimulate others toward explanations, and these may, in turn, contribute to the growing awareness of performance involving video presentations.

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Table 1

Confusion Matrix for Dot Font

	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	.47	.01	.01	.00	.01	.01	.01	.24	.01	.01	.02	.03	.06	.06	.00	.02	.00	.04	.00	.01	.01	.00	.00	.00	.00	.00
B	.01	.51	.01	.21	.06	.01	.01	.01	.00	.00	.00	.02	.01	.01	.02	.05	.00	.01	.02	.01	.03	.01	.00	.00	.00	.00
C	.00	.06	.47	.12	.04	.01	.09	.01	.01	.00	.01	.03	.00	.01	.04	.01	.03	.02	.01	.01	.02	.01	.00	.00	.01	.00
D	.02	.11	.01	.61	.03	.00	.00	.00	.02	.00	.00	.03	.00	.02	.06	.01	.02	.03	.00	.01	.02	.01	.01	.00	.00	.00
E	.00	.04	.03	.02	.59	.08	.01	.00	.03	.00	.01	.11	.01	.01	.01	.01	.00	.01	.01	.03	.00	.00	.00	.00	.00	.00
F	.01	.01	.01	.02	.05	.47	.00	.02	.04	.00	.03	.05	.01	.02	.01	.10	.00	.05	.01	.07	.00	.00	.00	.01	.00	.01
G	.03	.12	.04	.06	.06	.01	.40	.00	.00	.01	.02	.03	.01	.01	.03	.00	.06	.03	.05	.00	.03	.00	.00	.00	.01	.01
H	.04	.01	.00	.00	.01	.00	.00	.44	.02	.00	.00	.02	.12	.22	.00	.01	.00	.01	.01	.01	.02	.01	.06	.00	.01	.00
I	.00	.00	.01	.00	.03	.02	.00	.00	.57	.03	.00	.10	.00	.02	.00	.01	.00	.01	.02	.12	.00	.01	.00	.01	.03	.02
J	.00	.01	.02	.03	.01	.00	.01	.00	.04	.56	.01	.04	.01	.01	.00	.01	.01	.01	.01	.00	.21	.02	.01	.00	.00	.00
K	.01	.01	.01	.00	.02	.01	.00	.02	.06	.00	.48	.05	.02	.05	.00	.02	.00	.14	.00	.03	.00	.02	.02	.02	.02	.00
L	.00	.02	.03	.01	.10	.00	.00	.02	.07	.00	.01	.63	.01	.01	.00	.00	.01	.01	.01	.05	.02	.00	.01	.00	.00	.00
M	.02	.00	.00	.00	.01	.00	.00	.14	.00	.00	.01	.01	.44	.29	.01	.00	.00	.00	.00	.01	.03	.01	.04	.00	.00	.00
N	.02	.01	.00	.00	.00	.01	.01	.10	.01	.01	.01	.01	.22	.44	.00	.00	.00	.00	.01	.01	.03	.02	.12	.00	.00	.00
O	.00	.02	.02	.14	.00	.00	.03	.00	.00	.00	.00	.01	.00	.01	.46	.01	.16	.01	.01	.00	.13	.01	.00	.00	.00	.00
P	.01	.07	.01	.02	.01	.11	.01	.03	.03	.01	.02	.01	.01	.01	.01	.01	.48	.01	.06	.02	.07	.02	.01	.00	.00	.00
Q	.01	.02	.01	.09	.00	.00	.03	.01	.00	.00	.01	.01	.04	.01	.14	.01	.46	.02	.02	.00	.08	.01	.03	.00	.00	.00
R	.02	.03	.01	.02	.01	.06	.00	.03	.00	.01	.09	.03	.01	.03	.01	.09	.01	.52	.01	.01	.01	.00	.01	.00	.00	.01
S	.00	.07	.03	.04	.02	.01	.06	.00	.01	.03	.01	.03	.01	.01	.02	.00	.03	.00	.56	.01	.01	.02	.00	.01	.01	.06
T	.00	.00	.01	.02	.03	.02	.01	.00	.21	.01	.01	.05	.00	.01	.01	.03	.00	.02	.00	.54	.00	.00	.00	.01	.04	.01
U	.00	.00	.00	.02	.01	.00	.01	.04	.01	.06	.00	.01	.02	.06	.04	.00	.00	.00	.00	.00	.58	.07	.10	.00	.01	.00
V	.01	.01	.01	.00	.01	.00	.00	.00	.00	.01	.01	.02	.01	.01	.01	.00	.00	.01	.01	.00	.04	.52	.02	.02	.30	.01
W	.00	.00	.00	.02	.00	.00	.00	.19	.01	.00	.01	.01	.11	.16	.01	.00	.00	.01	.00	.00	.06	.01	.41	.01	.00	.00
X	.01	.01	.01	.01	.01	.00	.01	.01	.02	.01	.08	.06	.02	.06	.01	.01	.01	.03	.01	.03	.01	.04	.01	.44	.06	.04
Y	.01	.00	.00	.01	.01	.00	.00	.00	.04	.01	.00	.04	.00	.02	.00	.02	.00	.01	.01	.06	.01	.07	.01	.08	.58	.03
Z	.00	.01	.01	.00	.12	.01	.00	.01	.02	.01	.00	.05	.01	.02	.01	.01	.00	.01	.13	.01	.00	.01	.01	.01	.03	.55

Table 2

Confusion Matrix for Stroke Font

	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	.56	.01	.00	.01	.01	.01	.00	.13	.01	.01	.04	.03	.00	.03	.01	.01	.01	.02	.01	.01	.00	.00	.01	.06	.01	.03
B	.03	.41	.00	.15	.04	.00	.01	.02	.01	.00	.07	.04	.01	.01	.01	.06	.01	.07	.03	.00	.02	.01	.01	.01	.01	.00
C	.00	.00	.42	.01	.00	.00	.32	.00	.00	.00	.01	.03	.00	.01	.11	.00	.06	.00	.02	.00	.01	.00	.00	.00	.00	.01
D	.01	.12	.01	.59	.00	.00	.01	.01	.01	.00	.00	.02	.01	.00	.08	.01	.01	.01	.01	.00	.06	.01	.02	.00	.01	.00
E	.00	.09	.00	.04	.43	.06	.01	.01	.06	.00	.04	.09	.00	.01	.01	.04	.00	.02	.03	.04	.00	.00	.01	.00	.01	.01
F	.02	.03	.01	.01	.03	.33	.00	.03	.13	.00	.03	.07	.01	.02	.00	.12	.00	.08	.01	.06	.01	.01	.00	.00	.01	.01
G	.01	.00	.14	.01	.01	.01	.56	.00	.00	.02	.01	.00	.01	.01	.13	.00	.04	.01	.01	.00	.02	.01	.00	.00	.00	.00
H	.13	.02	.00	.01	.00	.00	.00	.49	.04	.03	.02	.04	.08	.07	.00	.01	.01	.03	.01	.00	.02	.00	.01	.01	.00	.00
I	.01	.02	.01	.00	.03	.00	.00	.00	.61	.00	.01	.15	.00	.01	.00	.00	.00	.01	.01	.10	.02	.00	.00	.01	.03	.00
J	.00	.01	.00	.03	.00	.00	.00	.01	.09	.52	.00	.02	.01	.01	.01	.01	.00	.00	.03	.08	.14	.00	.01	.01	.01	.00
K	.02	.02	.00	.01	.01	.01	.00	.02	.02	.01	.49	.02	.02	.01	.00	.01	.00	.22	.01	.00	.00	.01	.01	.09	.02	.00
L	.00	.01	.01	.03	.10	.00	.01	.01	.21	.01	.01	.46	.00	.00	.00	.02	.00	.01	.01	.05	.02	.02	.01	.00	.02	.01
M	.00	.01	.00	.00	.00	.00	.01	.04	.02	.00	.00	.01	.53	.27	.01	.00	.00	.02	.00	.01	.01	.03	.05	.01	.01	.00
N	.03	.01	.00	.00	.00	.00	.00	.04	.00	.01	.04	.01	.19	.52	.00	.00	.00	.02	.01	.00	.00	.02	.06	.03	.02	.00
O	.01	.01	.03	.07	.00	.00	.08	.00	.00	.01	.01	.00	.00	.00	.48	.00	.27	.00	.00	.00	.03	.00	.00	.00	.00	.00
P	.01	.08	.00	.05	.00	.02	.01	.02	.04	.00	.02	.04	.01	.02	.00	.47	.01	.13	.00	.03	.01	.02	.01	.01	.01	.00
Q	.00	.00	.01	.03	.00	.00	.02	.01	.00	.00	.01	.00	.00	.00	.33	.01	.51	.00	.01	.00	.06	.01	.01	.00	.00	.00
R	.02	.06	.00	.03	.01	.00	.00	.04	.04	.00	.21	.01	.02	.03	.01	.03	.01	.43	.01	.01	.01	.01	.00	.02	.00	.00
S	.00	.07	.02	.01	.03	.01	.01	.01	.01	.01	.02	.03	.01	.01	.02	.00	.01	.00	.62	.01	.00	.00	.01	.03	.01	.08
T	.01	.01	.00	.02	.03	.03	.00	.01	.28	.01	.01	.08	.01	.00	.01	.02	.00	.01	.00	.39	.01	.01	.00	.00	.07	.01
U	.00	.01	.03	.03	.00	.00	.02	.03	.01	.07	.01	.03	.01	.01	.09	.01	.01	.00	.02	.02	.51	.06	.02	.00	.01	.01
V	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	.01	.01	.00	.00	.02	.01	.01	.07	.60	.02	.04	.21	.01
W	.01	.01	.00	.00	.00	.00	.01	.00	.00	.00	.01	.00	.17	.03	.00	.00	.01	.01	.00	.00	.11	.06	.59	.01	.00	.00
X	.02	.00	.00	.01	.00	.00	.00	.01	.00	.00	.07	.02	.02	.04	.00	.01	.00	.01	.02	.00	.01	.09	.01	.56	.10	.01
Y	.00	.01	.00	.00	.00	.01	.00	.00	.02	.02	.01	.02	.01	.02	.01	.00	.00	.01	.02	.02	.01	.11	.01	.13	.56	.02
Z	.00	.00	.00	.00	.04	.01	.02	.00	.01	.01	.01	.04	.00	.02	.01	.00	.01	.02	.11	.01	.01	.02	.00	.07	.02	.56

Table No. 3

Dot vs. Stroke	SSE
Along main diagonal	.234
Off diagonal	.555
Total	.789

Table No. 4

	Condition			Sum Square Error Based on			
				Direct Computation		Indirect Computation	
Line No	Font	Medium	Subjects	Source	SSE	Basis	Value
1	S	S	D	Townsend	0.80		
2	D	S	S	This Study (Dots vs. stroke)	0.79		
3	S	D	S	--No study available	N.A.	line 5 SSE - line 1 SSE	1.05
						line 7 SSE - line 4 SSE	1.51
						line 7 SSE - line 1 SSE - line 2 SSE	1.17
4	D	S	D	This Study (Dots) vs. Townsend	1.25	line 1 SSE + line 2 SSE	1.59
5	S	D	D	This Study (Dots) vs. Gilmore et al.	1.85	line 7 SSE - line 2 SSE	1.97
6	D	D	S	--No study available	N.A.	line 7 SSE - line 1 SSE	1.96
7	D	D	D	Gilmore et al. vs. Townsend	2.76	line 2 SSE + line 5 SSE	2.64

Legend: S: Same
D: Different
Font: Either Dots or Stroke
Medium: Either video screen or projection on white screen