Do pen characteristics affect writing performance?

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This study is an attempt to determine the optimum dimensions of ball-point pens for writing in Chinese and English languages. A total of 36 "bare-bodied" pens and 20 Chinese subjects were used to evaluate the effects of shape, size and weight on a speed variable and three subjective ratings when writing in both English and Chinese languages. The results indicate that the Chinese prefer a circular shaped pen. In addition, the subjective ratings for the pens differ depending on the language written. The factor analysis shows that speed, comfort and writing ability are independent parameters in pen evaluations.

1. Introduction

Goonetilleke et al (1996) reported a study where pen shape and size were investigated in a drawing task. In that study, the hexagonal cross-sectional pen was worst for accuracy and smaller size of pen had best accuracy but lowest speed. This research was aimed at investigating the effect of writing speed and perceived ratings when using pens of different weight, size, and shape and writing in two different languages, English and Chinese.

2. Methodology

2.1 Equipment

A total of 36 pens were fabricated from three sizes of circular aluminum stock (see Figure 1). Six different shapes of pens were made: circular (c), hexagonal (x), octagonal (o), triangular (t), elliptical (e), and square (q). Each of these shapes were made in three sizes (Table 1): small (cut from 7.5mm diameter stock), medium (cut from 9 mm diameter stock) and large (cut from 10.5mm diameter stock). The design of each pen was such that the middle portion of the pen shank could be fitted with one of two different (light and heavy) weight sections (Table 2).

Table 1. Cross-sectional area (mm^2) of different shape and size pens

Shape	small	medium	large
triangular (t)	21.303	27.747	35.474
square (q)	29.658	40.857	55.890
elliptic (e)	30.008	43.388	60.133
hexagonal (x)	37.047	53.266	70.721
octagonal (o)	39.013	56.447	75.882
circular (c)	44.467	64.05	87.196

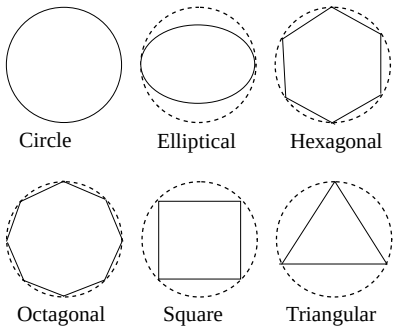


Figure 1. Shape cut from circular cross-section

Table 2. Weight (grams) for the different size and shape of pens

Shape	Light			Heavy			Light	Heavy
	small	medium	large	small	medium	large	(mean)	(mean)
triangular (t)	10.80	16.89	23.55	19.50	30.40	42.84	17.08	30.91
square (q)	11.04	17.45	24.85	19.74	30.96	44.14	17.78	31.61
hexagonal (x)	11.70	18.50	25.93	20.40	32.01	45.22	18.71	32.54
elliptic (e)	11.70	18.43	26.61	20.40	31.94	45.90	18.91	32.74
octagonal (o)	12.05	18.83	26.31	20.75	32.34	45.60	19.06	32.89
circular (c)	12.23	19.37	27.61	20.93	32.88	46.90	19.73	33.57

2.2 Subjects

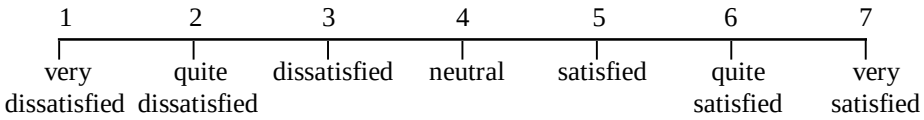
A total of 20 undergraduate and postgraduate Chinese students (16 from Hong Kong and 4 from the Peoples Republic of China) from the Hong Kong University of Science and Technology participated in the experiment. All subjects received a 5% credit in a related course for their participation.

2.3 Procedure

The order of pen presentation was completely randomized but counterbalanced to reduce order effects. Each subject was asked to write one English sentence, "This is the Department of Industrial Engineering and Engineering Management" and one Chinese sentence, " " using each of the 36 pens.

3. Results and Analysis

Four dependent variables were used. "Speed" was determined as the *Time* to complete the sentence. In addition to the speed measure, subjective evaluations relating to *Overall Comfort, Writing Ability* and *Overall Evaluation* were rated for each pen and writing language using the 7-point scale shown below.



Statistical analyses were performed using the SAS package. The factor analysis with varimax rotation showed the emergence of three factors. The first factor is heavily weighted by the two measures, *Overall Comfort* and *Overall Evaluation* (correlation between these two variables is significant at a probability of 0.05 with R^2=0.67), the second factor relates to *Writing Ability* and *Overall Evaluation* (correlation between these two variables is significant at a probability of 0.05 with R^2=0.67) while the third factor is almost solely dominated by the *Time* taken for writing. The three factors explain 94% of the total variation. A correlation analysis performed between the subjective measures and the *Time* measure showed no significant correlation ($R^2 < 0.1$). Hence it appears that *Overall Comfort, Writing Ability* and speed or *Time* are three distinct parameters in the evaluation of a pen.

Even though three different sizes and two weights were used, it is difficult to assume that the three sizes (small, medium and large) are consistent between the shapes since the cross-sectional areas of the pens were different unlike in the Goonetilleke et al (1996) study. As a result, the analysis of variance was performed using weight and size nested under each shape and assuming that weight and size were random factors. Hence the weight and size factors cannot be independently evaluated. The ANOVA showed no significant difference in

the *Time* variable for the factors, shape and the weight-size. However, the subjective ratings showed significant ($p < 0.05$) differences between the shapes and the weight-size factors. The circular cross-sectional pen was rated the best and the triangular pen the worst (both of these were significantly different from the others) for all three subjective ratings when writing in either language (Figures 2 and 3). Each of the shapes was further analyzed for differences between the 6 levels of weight and size (Table 3). Except for the triangular and hexagonal shapes, no significant differences were found for the subjective ratings when writing in English. For the circular cross-section, there exists a significant difference between the (light-weight, medium-size) pen and the (heavy-weight, large-size) pen for the two subjective ratings of *Overall Comfort* and *Overall Evaluation* when writing in Chinese (Table 3).

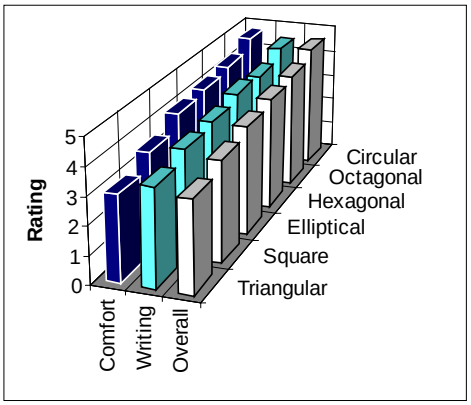


Figure 2. Subjective ratings when writing in Chinese language.

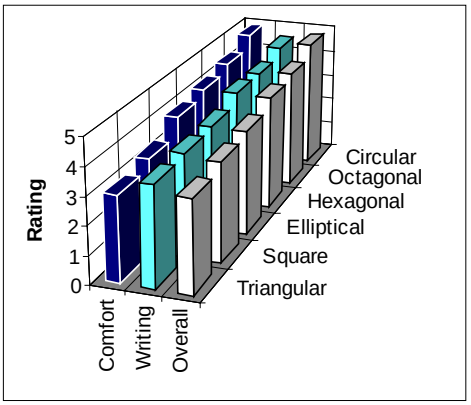


Figure 3. Subjective ratings when writing in English language.

Table 3. Student-Newman-Keuls analysis of weight-size factor for each shape

Rating & Language	Shape					
	Circular	Octagonal	Hexagonal	Square	Triangular	Elliptical
Comfort Chinese	3 5 2 1 4 6	1 3 2 5 4 6	x	1 4 2 3 5 6	1 4 2 3 5 6	x
Comfort English	x	x	x	x	1 4 2 3 5 6	x
Writing Chinese	x	x	x	x	x	x
Writing English	x	x	3 1 5 2 4 6	x	4 1 5 2 3 6	x
Overall Chinese	3 1 5 2 4 6	1 3 5 2 4 6	x	4 1 2 3 5 6	x	x
Overall English	x	x	1 3 2 5 4 6	x	x	x

Weight-Size factor notation in Table 3
1 = Light-Small
2 = Heavy-Small
3 = Light-Medium
4 = Heavy-Medium
5 = Light-Large
6 = Heavy-Large

x = no significant ($p<0.05$) differences exist between the six combinations of weight and size

4. Conclusions

The factor analysis shows that *Comfort*, *Writing Ability* and *Time* form a multi-dimensional set of ratings somewhat independent of each other. Of course, the surface texture of a pen and the legibility (measure of "accuracy") effects have not been evaluated. The circular shape is clearly preferred by the Chinese population for writing in both English and Chinese languages. The individual effects of weight and size were not compared in this study.

5. References

Goonetilleke, R. S., Wo, C. W., Hung, C. Y., and Kei, Y. L. (1996). Pen Design for Improved Performance. Proceedings of the 4th Pan-Pacific Conference on Occupational Ergonomics, Taipei, Taiwan. pp. 480-483.