Pen Design for Improved Drawing Performance

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ABSTRACT

This study is an attempt to determine the optimum shape and size for the shank design of ball-point pens. A total of 9 pens and 27 subjects were used. Drawing performance was measured by having the subjects follow a maze of different size. The dependent variables were drawing speed and drawing "accuracy". The results indicate the following:

1. The smaller size of pen makes the least number of errors (best accuracy) during drawing.
2. The smaller size of pen has the lowest speed
3. The hexagonal cross-section is the worst for accuracy, when compared with the circular and elliptical sections.

Even though larger size pens tend to be preferred by users, their performance in terms of accuracy tends to be low. The proper selection of a pen depends on its usage, and expectation. Objective specifications on drawing pens giving accuracy and speed for a standardized task would be extremely valuable to artists and designers who may need a specified level of accuracy during free-hand sketching.

Keywords: Pen-design, pen-size, pen-cross-section, shank-design, human-performance

1. INTRODUCTION

The design of handwriting instruments has been based primarily on touch, feel, and aesthetics. The published literature is very limited (Kao, 1977), and are related to writing instruments that are commercially available. For example, Kao (1976) has investigated the effect of hand-writing quality with lead pencils, ball-point pens and fountain pens. In two other studies (Kao 1977, 1979), he has looked at the effects of writing time, writing pressure, and writing efficiency with ball-point pens, pencils, felt pens, fountain pens and with pen point shape variations. The primary conclusions in these studies have been the following:

1. Ball-point pens were the best (lowest) and fountain pens the worst (highest) for writing speed.
2. Writing pressure was highest with ball point pens and lowest with felt-tip pens.
3. In terms of the tip design, the pen contact time was lowest for tilted points followed by straight points and then curved points.

None of the above studies have investigated the effect of shank design on writing performance which becomes important if pen-point pressure is a factor related to writing. However, Kao (1979) does mention that pen shafts with larger diameter tend to be preferred.

The pressure exerted on the writing surface depends, to a large extent on the pinch grasp used by a subject. Even though hand grip strength (Greenberg and Chaffin, 1977; Ayoub and Lo Presti, 1971) variations with grip size has been extensively investigated, the effect of pinch grasp on writing pressure has yet to be determined. The primary goal of this research was to examine the effect of shank design (shape and size) on drawing "accuracy" and drawing speed.

2. METHODOLOGY

2.1 Equipment

A total of nine pens were fabricated. Theses pens had three different cross sectional areas: circular, elliptical and hexagonal. Each of the shapes were made in three sizes: large (cross sectional area of 320 mm^2), medium (cross sectional area of 180 mm^2), and small (cross sectional area of 50 mm^2).

2.2 Subjects

A total of 27 undergraduate students at the Hong Kong University of Science and Technology were used as subjects in the experiment. Two of the subjects were left-handed and all others were right-handed.

2.3 Procedure

The order of pen presentation to each subject was completely randomized with each subject testing all of the nine available pens. Three different sizes of mazes (D1, D2, and D3; See "Experiment Sheet") were used to determine pen performance in terms of writing "accuracy" and writing speed. The subjects were randomly assigned to one of three groups and each group was tested on one "Experiment Sheet" shown later. The three types of sheets (i.e., Type 1, Type 2, and Type 3) showed the three types of mazes (D1, D2, and D3) in the following sequence:

Type 1 - D1 (large maze), D2 (medium maze), D3 (small maze)
Type 2 - D2 (medium maze), D3 (small maze), D1 (large maze)
Type 3 - D3 (small maze), D1 (large maze), D2 (medium maze)

Each subject did three trials with each size of maze. Hence each subject used each pen to draw on a total of 9 mazes (3 different sizes of maze with three repetitions on each size). Each subject was instructed to use the pen and draw as fast as possible and as accurately as possible.

3. RESULTS

The two dependent measures were the drawing speed and the drawing accuracy. Speed was determined as the time to complete the maze moving from the outside entry point, back to the outside through the center of the maze. Accuracy was defined as the number of cross-over points with the printed lines on the maze, when performing the drawing. A touch was considered as one error while a cross-over of the maze outline was considered to be two errors.

Statistical analyses were performed using the SAS package. The "speed" variable shows significant effects ($p < 0.05$) for pen size, $F(2, 2160) = 11.97$; and type of drawing maze, $F(2, 2160) = 64.97$. A Student-Newman-Keuls test showed that the differences in size were between the smallest cross-section and the other two cross-sections. The smaller cross-section was the slowest for drawing performance. There was no significant difference between the medium and large cross-sections. Further analysis on the type of maze showed significant difference between all three types, with the fastest time on the largest maze and the slowest time on the smallest maze. This result is not surprising. Shape had no significant effect on the dependent variable, time.

The results were somewhat different for the "Accuracy" variable. The interaction of (size * diagram) was significant at the $p < 0.05$ level, $F(4,2160)=18.02$. This interaction effect is shown in Figure 1. In addition, shape, $F(2, 2160) = 3.61$; size, $F(2, 2160) = 73.97$; and type of maze, $F(2, 2160)= 396.15$ were also significant at the $p < 0.05$ level. The hexagonal shape had the highest number of errors, and significantly different from the circular and elliptical shapes. As seen from Figure 1 below, the highest accuracy was with the smallest size pen and the largest maze.

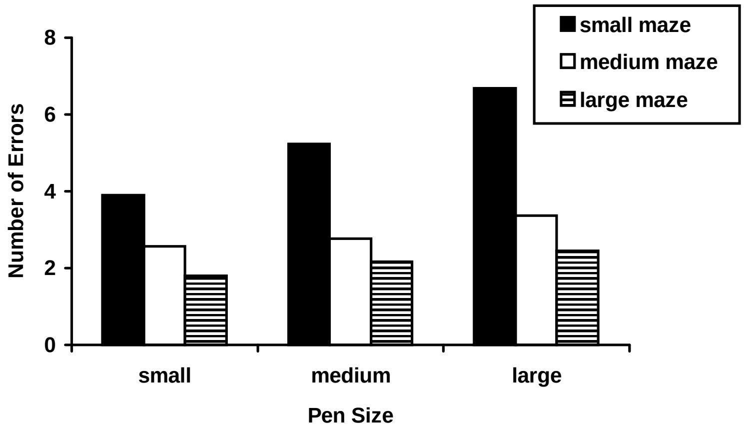

Figure 1. The interaction between size of pen (small, medium and large) and type of maze (small, medium, and large).

4. DISCUSSION AND CONCLUSIONS

To summarize, the important findings are as follows:

1. The hexagonal cross-section is the worst for accuracy, when compared to the elliptical and circular cross-sections
2. The smaller size of pen makes the least number of errors (best accuracy) during drawing; the larger size has the least accuracy and
3. The smaller size of pen has the lowest speed

Most daily writing needs are based on speed rather than accuracy. Hence it would not be surprising to find that the writing instrument preference to be towards larger size pens since the speed is higher. The preference seen in previous studies (Kao, 1979) may be attributed to speed.

In concluding, it may be said that a specification based on a standardized task may be helpful in writing instrument selection. Such a specification on pen performance is extremely valuable to artists and designers who need a specified level of accuracy during free-hand sketching.

5. REFERENCES

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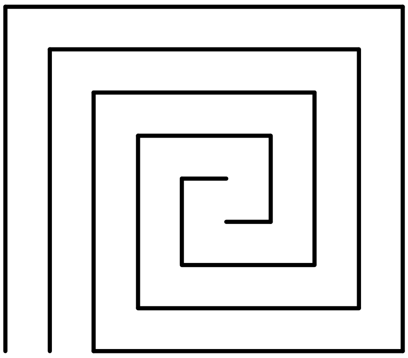
<u>Experiment Sheet (Type 1)</u>

Subject Number :_____ Pen Number :_____ Date :_____________

Please complete each of the following diagrams
as fast as possible and as accurately as possible using the pen provided.

D1



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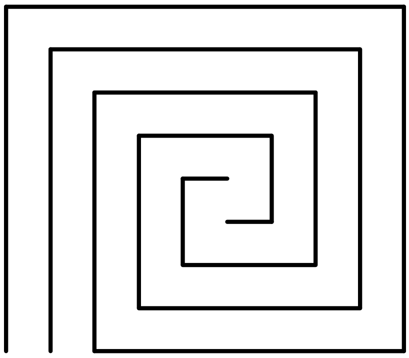
Time:_______ (s) Error:_____



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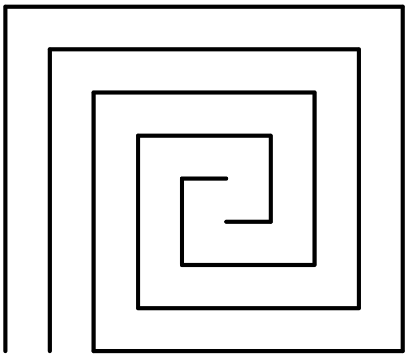
Time:_______ (s) Error:_____



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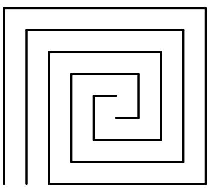
D2



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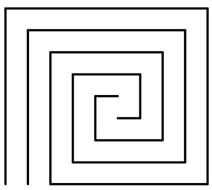

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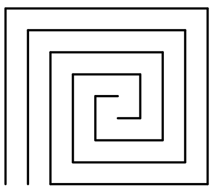

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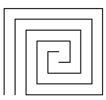
D3



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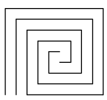
T:______ E:_____



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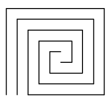
T:______ E:_____



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