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Dial Legibility as a Function of Scale Graduation and Dial Shape

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Abstract. The study of dial legibility in terms of accuracy of reading has been carried on from two approaches. In one of these the dial shape is varied, while the graduations are held constant. The other approach is to hold shap constant and to vary the number of graduations. The present study presents a combination of the two earlier approaches, with shapes and graduations both being varied.

Sixty dials were presented in booklets to forty Ss, who read them to the nearest 0.1 cm. while being timed. The results indicate that in dial reading situations where exposure time is not limited there is a significant difference among graduations but not among dials.

Studies of Sleight (1948) and Graham (1956) set a pattern for investigations of dial legibility as a function of dial shape. Sleight tachistoscopically presented dials drawn with India ink on white paper. He used a standard scale length, equal proportions, identical numbers, and movable pointers. He defined legibility in terms of the percent of errors for each design. In his summary of studies done during World War II, Sleight pointed out: that mid-division lines which changed from one part of the scale to another increased error, that accuracy decreased as the number of scale divisions increased, that numbering of scale sub-divisions tended to increase accuracy in timed exposures, that the starting point of a scale did not affect legibility, and that reduction in width of a pointer which blocked markings did not improve accuracy. Graham's (1956) study indicated that horizontal dials were more easily read correctly than were circular or vertical dials when presented in a tachistoscope.

Grether (1949) solved the problem of how to present efficiently a large number of dials to many subjects at once by preparing printed booklets with the dials arranged in a random fashion through the booklet. Grether's study was of dial legibility as a function of scale graduation. He found that the booklet presentation was as reliable as tachistoscope presentation for his type of study.

The earlier studies have generally limited the variables to either dial shape or scale graduation, with the other variable held constant. The results of Sleight's (1948) study, for example, show that the most legible dial shape is the open-window, followed by

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the round, semi-circular, horizontal, and vertical, with percent errors from 0.5 per cent to 35.5 percent. McCormick (1957) reports that Kappauf, Smith and Bray have shown that dials graduated by five's are read more accurately than those graduated by one's or ten's, with percent errors ranging from 13 percent to 25 percent. The difference between five's and one's was not significant, while the difference between either five's or one's and ten's was highly significant. McCormick also cites a study by Vernon, in which greatest accuracy in reading was with a scale graduated for each of the scale units to which the scale is to be read. Other studies have dealt with the scale graduation variable and legibility (Chapanis, 1947; Yeyzorek, 1949; Chapanis and Leyzorek, 1950) with similar conclusions.

The purpose of the present study was to determine the exact relationship between scale graduations, dial shapes, and the legibility of the dials. The objective was to test whether or not the findings of the earlier research could be replicated in a study which, by design, combined the two variables, shapes and graduations.

Legibility was defined in terms of accuracy in reading. The design read with the smallest percent error was taken to be the most legible. Fifteen dial designs were prepared using the five dial shapes found by Sleight to be the most common, and the three methods of graduating the scales of the dials as reported in Kappauf, Smith, and Bray. On the basis of the past studies, it was hypothosized that the open-window dials would be more legible than the other shapes, and that the one-unit interval graduation (every 0.1 cm. marked) would be more legible than the five-unit graduations.

METHOD

Subjects

The forty male subjects who participated in the study were volunteers from an introductory psychology class. Their ages ranged from seventeen to twenty-five. Subjects were tested in groups of from five to eight. In response to the questions on the cover page of the booklet, one subject responded that he did not drive a car, and five of the thirty-nine card drivers had some dial reading experience beyond auto or tractor driving. One of these five was an airplane pilot, while the other four had worked in quality-control or measurement jobs. These five subjects with job-connected dial reading experience performed no better than the rest of the group.

Stimulus Material

Each subject was given a test booklet of seven pages. The cover page presented instructions for reading the dials and ques-

tions regarding biographical information. Inside the booklet were sixty dials, two dials of each type on each page. Each dial's scale was ten centimeters long, and was numbered from 0 to 10. The scale markers were: for graduations placed at 1.0 and 0.5 cm., 1/8 inch long; for graduations at 0.1 cm., 1/16 inch long. The five shapes used were: open-window, vertical, round, semi-circular, and horizontal (Sleight, 1948). All dials on a page were graduated in the same manner, with markers at each 1.0 cm., each 0.5 cm., or 0.1 cm. Pages were shuffled in the assembly so that no two consecutive pages were graduated in the same manner. A standard pointer, 1/16 inch wide and 9/16 inches long, was used on every dial. The sixty readings which were indicated by the pointers were drawn from a table of random numbers (Snedecor, 1959).

Procedure

Each subject was requested to complete a personal information questionnaire which included these questions: "Do you drive a car?", "Have you ever had a job which caused you to read dials?", and "Where?". The experimenter read the printed directions aloud, then requested that the subjects read the sample semi-circular dial to insure that the directions were understood. The experimenter started the subjects simultaneously and timed them. Subjects were given all the time they required to complete and check their booklets.

A key, prepared from the original pointer settings on the dials, was used for scoring the responses. The percent error was computed for each dial and these percents were transformed to the arcsin for purposes of data analysis.

RESULTS AND DISCUSSION

The analysis of variance performed on the transformed data is shown in Table 1. It can be seen that the main effect for graduations produced an F significant beyond the .01 level. The dials graduated every 0.1 cm. were most legible (12.5% error). The 0.5 cm. graduations were the next most legible (16.1% error the 1.0 cm. graduations were the least legible (35.0% error). It should be noted that the difference between 0.5 cm. graduations and 0.1 cm. graduations was not significant. These results correspond closely to the finding of earlier investigators and supported that portion of the second hypothesis which stated that the one-unit graduations would be more legible than the ten-unit graduations. They did not support that part of the hypothesis which predicted greater legibility for the one-unit graduations than for the five-unit graduations.

Neither the shape main effect nor the interaction between graduations and shapes was significant. The non-significant

Table 1.   Analysis of variance of percent errors transformed to the arcsin.

Source	Degrees of Freedom	Mean Square
Graduations (G)	2	1228.7**
Shapes (S)	4	130.5
G by S	8	315.4
Error	45	216.9

** Significant beyond the .01 level.

main effect for shape was not expected in view of the marked differences in shape legibility found by such investigators as Graham (1956) and Sleight (1948). It should be noted that the present study employed a different stimulus presentation method (booklet vs. projected movies or tachistoscope) and a longer exposure time per stimulus (unlimited exposure time with the minimum being 3 to 4 seconds vs. fractions of a second). Sleight (1948) indicated that restriction in exposure time to 0.12 seconds was necessary to produce a high enough error rate for his investigation. It was pointed out earlier that the booklet presentation method was as satisfactory as other techniques when used for determining the effects of different scale graduations on legibility. However, it does not appear appropriate for investigation of the shape variable in the light of the long exposure times inherent in using the technique. A more adequate test of the effect of combining the two variables would seem to necessitate the use of limited exposure times. The main implication of the present study, therefore, would be that in dial reading situations where exposure time is not limited, the shape of the dial is irrelevant. Broader conclusions await a test of the type indicated above.

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