The Peripheral Viewing of Dials

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The long series of studies of pilot eye movements conducted at the Psychology Branch of the Aero Medical Laboratory (1) has shown that the amount of time spent by pilots in the reading of any particular instrument in flight is much shorter than the time taken by Ss in a laboratory situation. The laboratory studies have used tachistoscopic exposure of dials in which the Ss controlled the exposure duration. The pilot eye fixation studies recorded the time that the pilots were fixated on a given instrument in actual flight conditions. One explanation which has been advanced (2) to account for this discrepancy is that the pilot has been able to develop, on the basis of previous experience, a set of expectancies about the indication on an instrument at any specified time. The S in the experimental situation, on the other hand, is presented with randomly selected and independent pointer settings, and is unable, because of the very design of the experiment, to formulate any hypotheses or expectancies. Once an expectancy has been formulated, the principal function of a fixation on the instrument may be merely to confirm or reject it—a function which can be accomplished far more quickly than a quantitative reading. Furthermore, there is experimental confirmation of the fact that expectancies do reduce errors in instrument reading (2).

In the operational situation, instruments remain continuously present in front of and around the operator even though he is not fixating them. If the images of these instruments, falling on the periphery of the retina, convey some information, then the range of possible alternative pointer readings is reduced and expectancies are formulated. This study is designed to determine the relationship between the efficiency with which a dial can be used, and the extent of the displacement of the image of that dial from the fovea.

Apparatus

The apparatus consisted of a modified perimeter upon which simulated dials could be presented. Starting at a lateral displacement of 10°, the perimeter was marked in 10° intervals to a lateral displacement of 80°. A stimulus card holder, containing a simulated dial face, could be placed upon any one of these marked intervals. A red point of light of low intensity was used for a fixation point. The Ss were provided with a headrest and chin support, and with a pistol-grip switch which turned on a light to illuminate the dial. This switch in turn controlled a 1/100-sec. clock, which recorded the time during which the dial was illuminated.

The stimuli consisted of white circles painted upon black cardboard octagons. Within each circle was a white pointer, the position of which could be changed by a rotation of the octagon. No graduation marks or numbers appeared on these simulated dial faces. Four different pointer designs were used; three were conventional pointers whose widths were .05, .1, and .2 in. The fourth pointer design had the same area as the .1-in. pointer, but tapered uniformly to the tip—i.e., it was double width at the broad end and effectively zero width at the top. At a 25-in. viewing distance, the dial subtended a viewing angle of 7.5°. When illuminated, the white circle and pointer had a luminance of 5 foot-lamberts.

Results from four Ss, experienced in psychological experimentation, are included in the data analysis. Data from one S, who was found during the experiment to have anomalous peripheral vision, were excluded.

Procedure

The S was seated at the apparatus and fixated the red fixation point. Monocular vision was used throughout. When the stimulus card was placed on

1 Now at The Ohio State University.
the right side of the perimeter, the right eye was used, and when on the left side of the perimeter, the left eye was used. In almost total darkness the E placed the stimulus card upon one of the marked positions of the perimeter. He then gave a “ready” signal, and the S actuated the pistol-grip light switch which illuminated the dial and started the clock. When he had read, or thought he had read, the pointer position, he released the switch, which turned off the light and stopped the clock. The S’s verbal report was one of eight compass headings—“north,” “northeast,” etc. Each dial was presented to each S 64 times—once at each combination of angular displacement of the stimulus and position on the pointer. Since four pointer designs were used, each S made a total of 256 readings. The order of presentation of the stimuli was determined in advance by random number tables.

Results

Results are analyzed in terms of time and errors. An error was any response other than the correct one, but two kinds of errors were tabulated separately. These were (a) a reversal error, which is reported pointer position differing from the correct one by 180°—e.g., a report of “northeast” for “southwest,” and (b) any other error. Pointer sizes, of the range used, were not significantly differ-

![Graph](image-url)

Fig. 1. Time and total errors in estimation of pointer position as a function of the
Fig. 2. Proportion of reversal errors and true errors in estimating pointer position as a function of the peripheral angle of view.

Discussion

The functions plotted in Fig. 1 of time and total errors are linearly related to angle of displacement with the exception of the high values attributable to the blind spot. Of course, the error function must eventually reach and stay at 87\% (pure chance), and the time function becomes indeterminate depending only on the willingness of S's to make guesses quickly or slowly.

Figure 2 shows the three-way breakdown of responses described above. It is evident that nonreversal errors remain less than 2\% until the peripheral angle of view is greater than 40°. Reversal errors, on the other hand, comprise approximately 20\% of the responses at 30° and 37\% at 40°.

The findings of this study have application in the design and arrangement of instruments.
on an instrument panel. If one is concerned with instruments in which the pointer movement is limited to less than 180° or the rate of change is slow, then an observer can discriminate among settings which differ by 45° almost perfectly even when the instrument is displayed as much as 40° from the line of sight. It should be noted that even at 80°, over twice as many responses are correct as would be predicted on a chance basis. In a situation where an operator is continuously tracking a particular instrument but also has a monitoring task of other instruments, such monitoring would be possible with minimum time demands if these instruments are of the moving-pointer type and if they are within 40° of the primary instrument. If the instrument-pointer alignment principles were employed (e.g., all pointers aligned at 9 o'clock for desired values), an operator can probably fixate a single display and simultaneously monitor other instruments peripherally up to 40° from the central field.

Summary

The ability of Ss to see pointer position for four types of pointers at peripheral angles from 10° to 80° has been investigated. No significant differences exist among the pointers used in this experiment. If reversal errors are ignored, the ability to discriminate pointer position when the dial is displaced as much as 40° from the fixation point is good. Even at 80° of displacement pointer position readings are better than chance.

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References