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THE EFFECT OF PRACTICE ON THE SPEED AND ACCURACY OF EQUIDISTANCE-SETTINGS

By ALFRED LIT and W. M. VICARS, Southern Illinois University

Because few reports have been published on practice effects in depth discrimination, we thought it would be desirable to obtain quantitative data during the training period of a program on binocular space discrimination which could demonstrate how these discriminations are influenced by practice.[1]

The specification and control of practice have been a persistent task for classical psychophysics, and the early experiments in this area have yielded quantitative data on this problem.[2] Military interest in the effects of training on depth-discrimination also has generated a considerable number of experimental studies.[3] These studies reveal that practice typically leads to no systematic change in mean position of equidistance-settings. Response variability, however, decreases to a low value with extended practice. No experimental studies were found in which the speed of equidistance-settings was measured as a function of practice. Accordingly, the present study was designed to yield quantitative data on both the speed and accuracy of equidistance-settings obtained from two inexperienced *S*s during an extended training period.

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[1] Cf., for example, recent reviews by E. J. Gibson, Improvement in perceptual judgments as a function of controlled practice or training, *Psychol. Bull.*, 50, 1953, 401-431; Perceptual learning, *Ann. Rev. Psychol.*, 14, 1963, 29-56.

[2] W. N. Kellogg, An experimental comparison of psychophysical methods, *Arch. Psychol.*, 17, 1929, 1-86.

[3] See, for example, A. H. Holway, D. A. Jameson, M. J. Zigler, L. M. Hurvich, A. B. Warren, and E. B. Cook, Factors influencing the magnitude of range-errors in free space and in telescopic vision, *National Defense Research Committee, Report to the Services Number 100, Division 7, Fire Control,* July 1945, 1-314; Norman Willard, Jr., C. A. Bancroft and J. G. Reddan, The training effectiveness of a stereoscopic range-finder trainer, *Human Resources Research Office, Technical Report 12,* Oct. 1954, 1-18; H. C. Olson and N. Willard Jr., A simplified method for rating the performance of stereoscopic range finder operators, *Human Resources Research Office, Technical Report 34,* Dec. 1956, 1-21; M. A. Schmitz, E. A. Stark and Norman Willard, Jr., Comparison of the stereoscopic range finder, M12 and the coincidence range finder T 43 as used in range determination at night, *Human Resources Research Office, Technical Report 53,* April, 1959, 1-26.

Apparatus and Procedure

The apparatus used to obtain the data has been fully described and illustrated in earlier reports.[4] It is essentially similar to the two-rod test device known as the Howard-Dolman apparatus.

The standard (stationary) target is a black vertical rod, .32 cm. in diameter, which is located at a distance of 100 cm. in the upper half of *S*'s visual field and is laterally displaced 1.3 cm (= 0.75°) to the right of his median plane. The comparison (fixation) target is a similar vertical rod located in the lower half of *S*'s visual field and is movable to and from *S* in the median plane. The bottom end of the upper rod and the top end of the lower rod touch a horizontal plane through the eyes of *S*. *S* is seated in a dark room and binocularly observes the targets through a pair of circular artificial pupils 2.5 mm. in diameter. Uniform background illumination (0.71 log troland) is provided by a lightbox located 250 cm. from *S*.

Two inexperienced undergraduate students with normal vision served as paid *S*s. In equating the apparent distance to the rods, *S* is required to fixate continuously on the top end of the lower rod and adjust this rod back and forth, using a 'bracketing' procedure, until it appears to lie in the same frontal plane as the upper standard rod.

The total training period was divided into two phases: an initial period consisting of approximately 18 experimental sessions and a terminal period consisting of about 10 experimental sessions. Five weeks separated the two training phases. Each experimental session lasted approximately for 2 hr. Following a 30-min. period of dark-adaptation, *S* was allowed to make as many groups of 20 consecutive equidistance settings as he could achieve within the remaining 1.5 hr. On the average, about five groups of 20 equidistance-settings were obtained from each *S* during a single experimental session. *S* was not aware of the fact that the time for making each equidistance setting was being measured. The instructions which were given emphasized only the need for accuracy of setting. The response-time for each equidistance setting began when the fixation-rod was adjusted by *S* to reach a position 10 cm. either in front of or behind the standard rod, depending on the direction of initial displacement. The response-time ended when *S* signalled the completion of his equidistance setting.

The mean and average deviation of each group of 20 settings was calculated using the linear distance from *S*. These values have been converted into a difference between the angular separation of the rods in one eye and the angular separation in the other eye.[5] These were averaged further for 10 blocks of 20 settings, as will be made clear below.

A corresponding procedure was used for the response times. In this case, the medians were determined for the time of the block of 20 settings, and the average deviation was determined within each block around the median response time.

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[4] Alfred Lit and Aaron Hyman, The magnitude of the Pulfrich stereophenomenon as a function of distance of observation, *Amer. J. Optom.*, 28, 1951, 564-580; Alfred Lit, Magnitude of the Pulfrich stereophenomenon as a function of target thickness, *J. opt. Soc. Amer.*, 50, 1960, 321-327; The magnitude of the Pulfrich stereophenomenon as a function of target velocity, *J. exp. Psychol.*, 59, 1960, 165-175. See also, H. J. Howard, A test for the judgment of distance, *Amer. J. Ophthal.*, 48, 1919, 461-474.

[5] C. H. Graham, Visual perception, in S. S. Stevens, (ed.), *Handbook of Experimental Psychology,* 1951, 888.

Results

(1) Effects of practice. The experimental results on the effects of practice on the accuracy of equidistance-settings are presented in Fig. 1. The

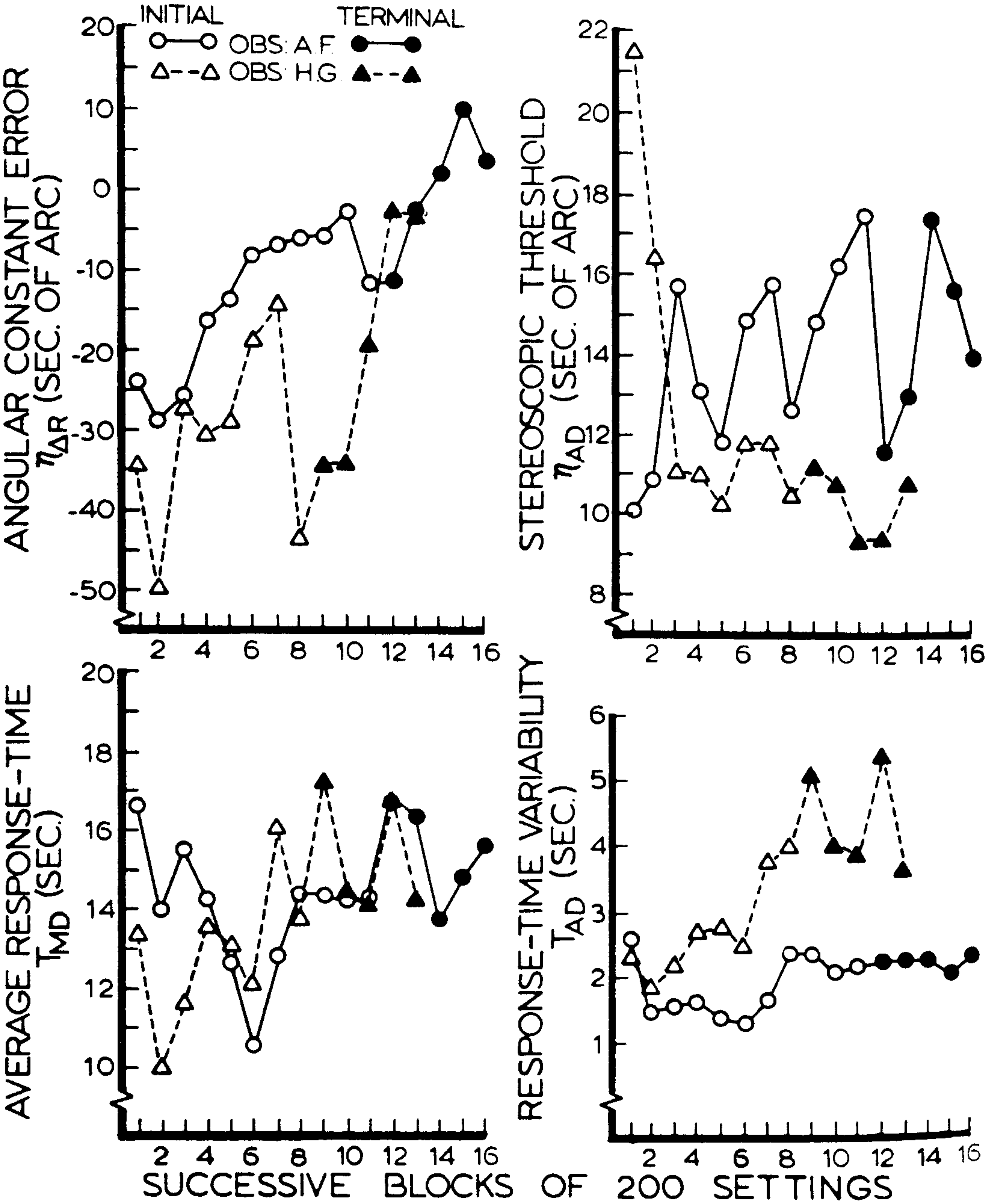

FIG. 1. EFFECTS OF PRACTICE ON THE SPEED AND ACCURACY OF EQUIDISTANCE SETTINGS.
Data for two *S*s are shown for both the initial period (open symbols) and terminal period (solid symbols) of practice for each of four response-variables.

magnitude of the constant error, in sec. of arc, and of the threshold as measured by the average deviation, are each shown as a function of practice. Each data point is based on a block of 200 settings, *i.e.* on the mean of 10 successive groups of 20 equidistance settings. For the threshold values, the mean is that of the average deviations within each group of 20 as described above.

From Fig. 1 it can be seen that each *S* initially exhibited a negative angular constant error (variable nearer to *S* than standard) which gradually reduced to zero as practice progressed through both phases of the experiment.

One *S*, (A.F.), gave threshold values that remained relatively low (about 14 sec. of arc) throughout both the initial and terminal phases of practice. For the other *S*, (H.G.), the threshold, that is, the mean average deviation, rapidly decreased from an initially high value of 22 sec. of arc to a final low value of 11 sec. of arc after only about 600 settings.

The experimental results on the effects of practice on the speed of equidistance settings are presented in lower half of Fig. 1. The median response time and that of the variability (average deviation) of the response times T are shown as a function of practice for each *S*. Each data point for median time is based on the average of the medians obtained for each of the 10 groups of settings. Similarly, the average deviations were averaged for the same 10 groups of 20 settings.

From this figure it is evident that, for both *S*s, both the median and its variability remained relatively constant throughout the experiment. The variability of H.G.'s times increased slightly from an initial value of 2 sec. to a final value of about 4.5 sec. A.F.'s time-variability was approximately constant for the entire experiment at about 2 sec.

(2) Intercorrelations among response-variables. Product-moment correlation coefficients (r) were calculated to determine the relationships existing among the four response-variables for each *S* during both the initial and terminal phases of practice. The correlation between the constant error and its corresponding response-time was essentially zero in all cases except for the initial practice-period for H.G. Here, r was $+0.17$. The grouped data similarly showed that no consistent relationship exists between the speed and accuracy of settings. The data revealed a slight but significant relationship between the constant error of the grouped settings and the corresponding variable error for A.F. ($r = +0.19$) for data obtained in the initial practice period and a slightly greater correlation ($r = +0.40$) for data in the terminal period. As expected, a moderate positive correlation was obtained between median response time and its variability ($r = +0.60$).

(3) Frequency-distributions of settings and response-times. The frequency-distribution polygons of the equidistance-settings and their response

times are presented in Fig. 2. The data for the first 1000 and the last 1000 responses are plotted separately in each case. It can be seen that each of the eight curves is essentially unimodal, fairly symmetrical, but somewhat leptokurtic.

Summary

Two inexperienced *S*s each made about 3,000 settings in a two-rod apparatus designed to test the threshold for binocular depth-perception.

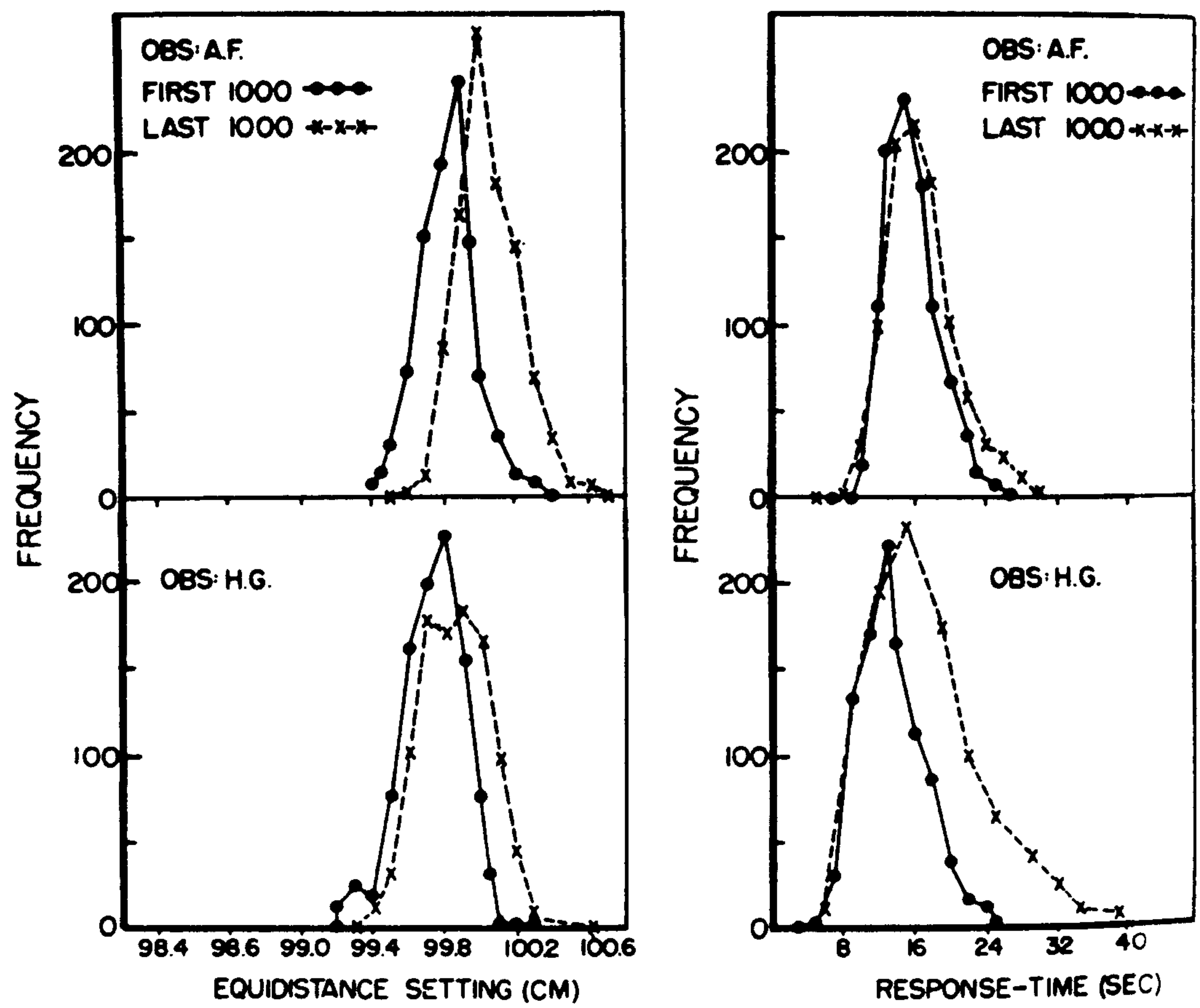

Fig. 2. Frequency-Distributions Obtained from Two *S*s on the First 1,000 and Last 1,000 Equidistance Settings
Standard target located at a distance of 100 cm.

The standard rod was located 100 cm. from *S*. The black targets were viewed against an illuminated background.

The results were analyzed in terms of both the constant and the variable errors of the settings. Unknown to *S*, the response-time for each setting was also measured.

The results show that the magnitude of the constant errors was initially roughly three times the threshold value and negative in direction for both

Ss. However, the constant error gradually approached zero with practice but without benefit of knowledge of results. The variable errors were also high for one *S* and declined rapidly. They were constant for the other *S*. The response-time for each setting rapidly reached a value of 15 sec. The intercorrelations among the response variables are essentially zero for both *Ss* except, of course, for the expected positive correlation between the median response-time and its variability.