Confounding of psychophysical errors and sensory effects in adjustment measures of spatial aftereffects¹

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Measurements of a stereoscopic spatial aftereffect using the method of adjustment without bracketing show that the linear regression of vertical adjustments on starting positions differs between pretests and posttests. The results are given an explanation in terms of two variables: rapid dissipation of the aftereffect and psychophysical adjustment errors. The implications of the results are discussed.

Adjustments of a rod initially tilted in an observer's (O's) frontal plane to a vertical target position have been shown to be relatively accurate when extraneous cues from the surrounding visual field are reduced to a minimum (Jastrow, 1893; Peirce, 1899; Neal, 1926). However, small but systematic deviations between adjustments and the objective vertical have been reported (Werner & Wapner, 1949; 1952a) and held to support a sensory-tonic theory of perception (Werner & Wapner, 1952b; Wapner & Werner, 1957).

O'Connell, Weintraub, Lathrop, and McHale (1967) obtained evidence contrary to this theory. They stressed the importance of starting position (SP) which they defined as the magnitude and direction in which the rod had to be moved to the target position. O'Connell et al showed that the SP determined the magnitude and direction of psychophysical errors of adjustment and they concluded that SP shifts altered the point of subjective verticality (PSV) "in a manner suggestive of adaptation level" (O'Connell et al, 1967, p. 350).

SP may be varied in three ways. First, the initial position of the rod may be changed over trials with a constant target position. Second, the initial position of the rod may be constant over trials and target position varied. Third, both the initial position of the rod and the target position may be varied over trials. In each case, the obtained setting to the target position would be predicted, from the results of O'Connell et al, to vary systematically with SP.

If psychophysical errors of adjustment vary with judged SPs, sensory spatial aftereffects (AEs) measured by adjustment techniques could be regarded as an instance of the second or third case. A sensory spatial AE occurs when prior stimulation by an inducing-stimulus (I-figure) modifies the judgment of some spatial property of a test-stimulus (T-figure). For example, Gibson and Radner (1937) showed that judgments of the vertical in the frontal plane following stimulation by a laterally tilted line (posttest) differed from judgments made prior to stimulation (pretest). They used the objective target position (vertical) as the pretest and posttest SP. Some other experimenters have either followed the same procedure (e.g., Morant & Harris, 1965; Singer & Day, 1965) or have used an SP other than the target position in the pretest and posttest (e.g., Singer & Day, 1966).

Under these conditions, if no AE occurs there should be no shift in the judged target position from pretest to posttest and any objectively equal pretest and posttest SPs should be judged equal. If an AE does occur, the posttest SP should be judged to differ from the pretest SP by some function of the induced AE. In general, pretest and posttest SPs should be judged equal only when they differ in the direction and by the amount attributable to the induced AE; and such judged equality should equate pretest and posttest adjustment errors. However, this condition of judged equality cannot be achieved prior to AE measurement since it requires knowledge of the size of the effect which the experiment aims to measure. When adjustment methods are used to measure AEs, therefore, part of the shift in the PSV may be attributable to differences between adjustment errors in the pretests and posttests. The determinants of these errors of anticipation (under-shooting) and habituation (overshooting) will be complicated by

the fact that AEs dissipate rapidly at first (Hammer, 1949; Singer & Day, 1965; Ganz & Day, 1965; Sagara & Oyama, 1957; Wenderoth, 1967). Not only will the judged target position be different in the pretest and posttest but the judged posttest target position will be changing while the adjustment is being made.

The purpose of the investigation reported here was to demonstrate that measurements of a spatial AE using the method of adjustment may result in a confounding of psychophysical adjustment errors and induced sensory effects. The particular AE studied was a stereoscopic effect induced by a contour slanted in O's median plane.

The T-figure was driven by a constant-speed motor so that larger SPs were associated with longer adjustment times. This procedure was considered preferable to one which fails to control the adjustment-time variable by allowing O to adjust at his chosen rate. For similar reasons, a method of adjustment without bracketing was used. Since the judged vertical shifts during posttest adjustment as the AE dissipates, bracketing, if permitted, may continue until the effect has dissipated almost completely (Köhler & Wallach, 1944, p. 304; Ganz & Day, 1965, p. 349). In addition, if bracketing is not restricted, the bracketing procedure used and thus the effective SP are determined entirely by O. The fact that bracketing reduces the magnitude of pretest adjustment errors (O'Connell et al, 1967) cannot be regarded as an argument for the use of bracketing in the posttest. If AEs measured by the method of adjustment without bracketing confound induced sensory effects with adjustment errors, then adjustment with bracketing simply increases the complexity of this interaction by eliminating the experimenter's control over the SP and adjustment-time variables.

METHOD

Subjects

Two of the authors were Os, Curthoys and Wenderoth. Both had stereoacuity better than 9.7 sec arc on the Bausch and Lomb Orthorater test. At the fixation distance of 27.5 in., Curthoys was slightly exophoric (3Δ) and Wenderoth was markedly so (8Δ), as measured by von Graefe's prism displacement test (Emsley, 1962, p. 82).

Apparatus

The apparatus, shown in Fig. 1, was housed in a wooden box 21 in. high and 35 in. square. The interior was divided into two compartments by a diagonal 7/8 in. septum which contained a 7-3/4 in. square aperture. The inside faces of the aperture were grooved to hold an 8 in. square semi-silvered mirror.

The T-figure was viewed through the mirror; the I-figure was reflected from it. The stimuli were mounted on 9-1/2 in. x 16-1/2 in. 20 gauge tubular steel frames. Spring clips attached to the frames supported .007 in. diameter steel threads; one at the horizontal axis of rotation and the other vertical and perpendicular to it. The point at which the two threads crossed served as the fixation point on both stimuli. Sheets of translucent perspex diffused light from pearl bulbs mounted behind each stimulus figure so that the threads were seen as shadows against a homogeneous ground. Brightness of both fields, measured by an S.E.I. photometer, was 80-85 ft-L. There was no shutter but the box was light-tight. A switch permitted illumination of either, both or neither of the chambers.

The centers of both figures were 14-1/2 in. from the center of the mirror and viewing distance for both was approximately 27-1/2 in. Aluminum occluding screens painted flat black were mounted 9 in. in front of the stimuli (shown by dashed lines in

Fig. 1. The apparatus.

Fig. 1). Rectangular apertures, 5/8 in. high and 2-1/16 in. wide, were cut into the screens and these subtended visual angles of 1 deg 54 min vertically and 6 deg 22 min horizontally. With both chambers illuminated, the aperture in the I-figure screen was visually aligned with the corresponding aperture in the T-figure screen. An additional occluder (not shown in Fig. 1) was interposed so that O could only see the aperture in the I-figure screen by reflection from the mirror.

O viewed the stimuli through a 4-3/4 x 1-3/4 in. aperture in the wall of the box. Head movements were restricted by a bite-board. Either E or O could vary T-figure slant by parallel switches controlling a reversible motor. When either switch was depressed the top of the T-figure began to slant away from O and raising either switch drove the frame in the opposite direction. A shaft to a 12 in. protractor at the rear of the box allowed T-figure settings to be read to the nearest 0.5 deg. There was some backlash in the system with a delay of 2.4 sec before the frame began to move when the direction of the switch was reversed. The motor drove the frame at a constant speed of 0.95 deg/sec. I-figure slant was controlled only by E by means of a shaft from the I-figure frame to the rear of the box.

Procedure

Pretraining. Because of the difficulty of the task, Os were given preliminary training in adjusting the T-figure to the objective vertical. After each adjustment, in Stages 1 and 2 of training, O was told the degree and direction of his setting from the vertical. He was then instructed to examine his setting for 2 sec but was not permitted to correct it.³ In Stage 1, O made adjustments from objective SPs of ± 10 deg, ± 20 deg, ± 30 deg and ± 40 deg until 10 consecutive settings were within ± 10 deg of the vertical (after 78 trials for Curthoys, 10 trials for Wenderoth). SPs were reduced to ± 5 deg, ± 7.5 deg, ± 10 deg and ± 12.5 deg in Stage 2, which continued until the variance of 10 consecutive settings was 4.0 or less (15 trials for Curthoys, 10 trials for Wenderoth). Feedback to O regarding the accuracy of his settings was omitted in Stage 3, which continued until O made 10 consecutive settings with variance 4.0 or less (30 trials for Curthoys, 10 trials for Wenderoth).

Pretest and posttest measures. The term "trial" is used to refer to a single AE measure consisting of a series of pre-stimulation adjustments, a stimulation period and a single post-stimulation judgment. On each trial, the pretest measure was the mean of four vertical settings, all from the same SP. The posttest was a single setting made from the same SP as that used in the pretest. Since Curthoys and Wenderoth served alternately as E and O, a method was devised which minimized the likelihood that O would detect the size of the SP on any trial. The four critical pretest settings were randomly embedded in a total series of 12 judgments half of which had a negative SP and half a positive SP. Though eight of

these settings were not used in the calculation of the AE, the variance of the series of 12 was required to be equal to or less than a criterion of 4.0. If the variance of the pre-stimulation settings exceeded this criterion stimulation was withheld, the trial was abandoned and O was retested with the same SP series on the next trial.

If the variance criterion was met, E switched to the I-figure which O then fixated for 90 sec. After 90 sec, E switched back to the T-figure which had been set, during stimulation, to the posttest SP and O made his posttest setting. The minimum time between trials for one O was 15 min and the maximum number of trials an O completed in a day was 10.

Experimental design. The AE was measured eight times at each of six I-figure slants, varying in steps of 10 deg from -32 deg to -82 deg. Each of the eight measures was taken from a different SP. The eight SPs used were: ± 5 deg, ± 7.5 deg, ± 10 deg, and ± 12.5 deg. The experiment was replicated twice giving, for each O, three identical blocks of 48 trials each. The pretest series of 12 SPs were different for each O and were different in each block. The 48 trials in each block were presented in random order, a different random order for each O and each block.

RESULTS

Pretest and posttest settings for blocks Curthoys (1) to (3) and Wenderoth (1) to (3) are shown in Figs. 2A to 2F. Each block was treated as a separate experiment and within the block pretests and posttests were analyzed separately.

For the analysis of pretests it was assumed that the four pretests on each trial were a simple random sample from a normal population and that the 48 samples of four settings were drawn from populations with a common variance. A test of randomness, involving the obtained and expected frequencies of inversions (Cochran & Cox, 1957, p. 575) indicated that this assumption was tenable in four of the six blocks. Cochran's test (Guenther, 1965, p. 219) indicated that the assumption of homogeneity of variance was tenable in five of the six blocks. Inspection of the results suggested that the departure from homogeneity in the remaining block, Wenderoth (1), was slight. The correlation between the pretest means and variances in this block was +0.05 and it was considered that any bias deriving from the use of pooled variance estimates in each block, including Wenderoth (1), would be negligible. An approximate test of normality was performed by expressing the 48 sets of four pretests in each block as deviations from their cell means and testing the 192 pooled deviations by the χ^2 goodness-of-fit technique. In each case, the null hypothesis that the distribution was normal was accepted. Table 1 presents a summary of the tests of the three assumptions.⁴

Six analyses of variance were performed on the pretest settings, one for each block, with the pooled variance estimate from the 48 cells as the error term in each analysis. The assumption of the independence of the four measures in each cell was considered justifiable on the basis of the tests of randomness and the fact that the four settings were randomly embedded in a longer series of judgments.

In order to analyze the posttest results an additional assumption was made. Each of the pretest data points in Fig. 2 is based on four measures but the posttest points are single measures only. It was assumed that the error variance associated with a posttest measure was the same as that associated with a pretest measure. Since both Os were highly trained this seemed a plausible assumption and the posttest measures were analyzed using the pretest error term of that block.

In all analyses, both pretest and posttest, the uncorrected sum of squares was first partitioned into two components: the corrected sum of squares and a component deriving from the general mean of the block. The latter served to test the null hypothesis that the general mean of the block was zero.⁵ The corrected sum of squares was further partitioned into two components: between SPs and between I-figure slants. The I-figure slants component has been included in the summary tables but will not be discussed here. Inspection of the data suggested analysis of the linear and residual trend components between SPs.

PRETEST / POSTTEST SP (deg)

Fig. 2. Pretest and posttest adjustments to the vertical. Figs. A to F show Curthoys blocks (1) to (3) and Wenderoth blocks (1) to (3), respectively. Pretest and posttest settings are joined by broken and solid lines respectively. Trials having different I-figure slant conditions are shown as follows: -32 deg (filled triangles); -42 deg (filled circles); -52 deg (filled squares); -62 deg (open triangles); -72 deg (open circles); and -82 deg (open squares).

These tests of trend were performed for each I-figure slant condition separately, using a method of unplanned contrasts (Rodger, 1967). I-figure slants were not expected to affect pretest settings since stimulation followed the pretests. However, pretests and posttests were analyzed in the same way in order to facilitate comparison between the results. The degrees of freedom between treatments, a , were 48 in every case (Rodger, 1967).⁶ The value $\alpha = 0.01$ was used in all tests. (Twelve tables summarizing the analyses of variance are on file in The Editorial Office of this journal. Copies may be obtained free by writing The Managing Editor.)

Over all six blocks, 36 tests of linear trend were performed on the pretest settings and 36 on the posttest settings. The null hypothesis that there was no linear trend between SPs was accepted in each of the tests on the pretests and was rejected in 18 of the 36 tests on the posttests. The linear regression coefficients calculated from the data in these 18 cases are shown in Table 2.

The assumption of the randomness of the pretest settings was rejected in blocks Wenderoth (3) and Curthoys (3) and it can be argued that these blocks ought not to be included in the treatment of results. There is a second reason also for arguing that the earlier

Table 1
Summary of Tests of Randomness
Normality and Homogeneity of Variance

Test		Block					
		ISC(1)	ISC(2)	ISC(3)	PMW(1)	PMW(2)	PMW(3)
Randomness	χ^2_{obt}	3.81	3.23	14.84	5.43	6.21	10.38
	df	4	4	4	4	4	4
	$\chi^2_{.95}$	9.49	9.49	9.49	9.49	9.49	9.49
Normality	Decision	A	A	R	A	A	R
	χ^2_{obt}	4.33	7.76	7.98	8.09	1.65	7.63
	df	8	8	8	6	6	6
Homogeneity	$\chi^2_{.95}$	15.51	15.51	15.51	12.59	12.59	12.59
	Decision	A	A	A	A	A	A
	C_{obt}	.087	.075	.076	.114	.056	.052
Homogeneity	df	48,3	48,3	48,3	48,3	48,3	48,3
	$C_{.95}$	.100	.100	.100	.100	.100	.100
	Decision	A	A	A	R	A	A

*There are 7 cells in each block for the frequency of 0, 1, 6 inversions. Cells 0, 1 were combined, as were cells 5, 6.

blocks only should be considered. Inspection of Fig. 2 suggests that changes in regression from pretest to posttest tended to decrease in magnitude from blocks (1) to (3) for both Os. If this is a real effect it could be due to some kind of learning in which O begins to compensate for past errors in judgment (e.g., overshooting of posttest adjustments from the -12.5 SP was reported by both Os in the early blocks: see Discussion of Results). This hypothesis has received some indirect support from another study in which naive Os showed marked regression changes from pretest to posttest while Wenderoth and Curthoys showed little or none at all.⁹

When blocks Curthoys (3) and Wenderoth (3) were excluded, 16 of the remaining 24 tests of posttest linear trend resulted in rejection of the null hypothesis. If all six null hypotheses about posttest linear trend were true in any block, the the probability of rejecting 0, 1 or 2 or more in that block would be 0.6130, 0.3867 and 0.0003, respectively, with $F_{.99}^{48} = 1.06$, $\nu_1 = 48$ and $\nu_2 = 144$ (Rodger, 1968). Since at least 2/6 null hypotheses were rejected in blocks (1) and (2) of each O it may be concluded that it is highly unlikely that all null hypotheses about linear trend were true in those blocks.

The null hypothesis that there was no systematic trend between SPs after the linear effect was removed was rejected in seven of the 36 pretest cases and three of the 36 posttest cases (4/24 and 1/24, respectively, if blocks (3) are excluded). Inspection of Fig. 2 indicates that pretest settings tended to undershoot the vertical from relatively large SPs (e.g., ± 12.5 deg) but to overshoot the target when SPs were close to the vertical (e.g., ± 5 deg). Perhaps a higher proportion of residual trend components would have been rejected in the pretests if the Os had not been trained and if the small variance criterion had not been employed.

The null hypothesis that the general mean of the block was zero was accepted in each pretest block other than Wenderoth (3). Figure 2F shows that the settings were generally slightly positive in that block. In the posttest analyses, this null hypothesis was rejected in all cases. The average posttest setting was negative in all cases, indicating that a significant AE had been induced.

DISCUSSION OF RESULTS

The main finding of this experiment was that the regression of vertical settings on SPs was markedly different in the pretests and posttests: the difference was essentially one of linear regression.⁸ If blocks Curthoys (3) and Wenderoth (3) are excluded, the slope of the posttest regression line was significantly positive in 16 of the remaining 24 tests, with no significant regression in the corresponding pretests. Therefore, the AE was larger the more negative the SP. On purely empirical grounds, it follows that any suggestion that regression effects would be removed by the use of an identical SP in the pretest and posttest is suspect.

An explanation of the changes in regression can be formulated in terms of the operation of two variables: AE dissipation and psychophysical adjustment errors. For simplicity, much of the following discussion is based on Curthoys' results.

Whenever the posttest SP was -12.5 deg, Curthoys initially judged the T-figure to be positively slanted. This can be inferred from the fact that he never moved it in the positive direction. However, following adjustment he often reported that the T-figure had "shot back" and that the final setting had therefore overshoot the judged vertical (the restriction on bracketing prohibited readjustment). On the other hand, when the posttest SP was +12.5 deg, Curthoys always moved the T-figure in the negative direction but in only two of 18 such adjustments did the setting reach -12.5 deg. Over the three blocks, Curthoys' average posttest setting from -12.5 deg was -17.56 deg with a standard deviation between blocks of 1.0 deg. The average setting from +12.5 deg was -9.44 deg with standard deviation between blocks 0.7 deg. The large difference between the two means can be explained in part by the fact that AEs dissipate in an "exponential" fashion. The average adjustment times from the -12.5 deg and +12.5 deg SPs were 7.1 sec and 24.7 sec, respectively. This suggests that the AE had dissipated to a greater extent when settings were made from the positive SP. Consequently, Curthoys made a less negative setting from the +12.5 deg SP.

However, even if the AE did not dissipate rapidly it would still be expected that posttest regression would differ from that in the pretest. If an AE were induced, SPs which were symmetrically situated around the pretest PSV would not be symmetrical around the posttest PSV. In this experiment, since the null hypothesis that the general mean of the pretest blocks was zero was retained in all blocks except Wenderoth (3), it is reasonable to suppose that the pretest PSV was near the objective vertical. Hence, the +12.5 deg and -12.5 deg SPs were relatively symmetrical about the pretest PSV. However, the same SPs were far from symmetrical about the posttest PSV: from Curthoys' judgments of the -12.5 deg SP immediately following stimulation it can be inferred that the +12.5 deg SP was at least 25 deg from the posttest PSV. O'Connell et al reported "an anticipation effect which varies with amount turned" and "a magnified anticipation effect and a less accurate point of subjective verticality . . . when backtracking is not permitted" (1967, p. 350). The judged asymmetry of the posttest SPs in the present study would therefore have resulted in greater undershooting from the +12.5 deg SP.

The results of block Wenderoth (3) indicate a complicating interaction between SP and AE. In this block the posttest adjustments of the T-figure were consistently in the positive direction when made from the -12.5 deg SP. This had the effect of giving the posttest regression lines a curvilinear appearance; and none of the null hypotheses about linear trend was rejected in this block. The curvilinear appearance raised the question of the form

Table 2
Coefficients of Linear Regression of Posttest Settings on SPs.
A = H_0 accepted.

$$Y = b_0 + b_1 X$$

Block	Coefficient	I-figure slant					
		-32°	-42°	-52°	-62°	-72°	-82°
ISC (1)	b_0	-12.65	A	-12.63	-12.38	-11.50	A
	b_1	0.44	A	0.73	0.52	0.38	A
ISC (2)	b_0	-14.44	A	A	-13.63	A	A
	b_1	0.41	A	A	0.47	A	A
ISC (3)	b_0	A	-13.94	A	A	A	-12.13
	b_1	A	0.40	A	A	A	0.36
PMW (1)	b_0	-6.19	-7.69	-8.00	-7.19	-8.06	-5.13
	b_1	0.28	0.39	0.34	0.54	0.37	0.46
PMW (2)	b_0	-6.19	A	A	-6.63	-4.38	-3.94
	b_1	0.31	A	A	0.44	0.60	0.36
PMW (3)	b_0	A	A	A	A	A	A
	b_1	A	A	A	A	A	A

of the regression when the AE induced in the negative direction is smaller than the larger negative SPs. It would be predicted that Os would move the T-figure in the negative direction from a positive posttest SP but would move it in the positive direction from a large negative SP. Hence the slope of the posttest regression line would be less positive than that obtained when a larger AE was induced.

A pilot study was performed in which Curthoys and Wenderoth were tested with a -12 deg I-figure slant. The procedures and methods were the same as those used in the main experiment. The results are shown in Fig. 3. The results are only suggestive. It has been pointed out that the Os may have learned to compensate partially for SP effects and none of the null hypotheses about linear or residual trend was rejected in this case. However, the calculated regression coefficients were -0.10 for both Os. Although these coefficients are not necessarily different from those obtained in the main experiment, the results do suggest that the slope of the posttest regression line may depend upon the size of the AE induced.

IMPLICATIONS

The hypotheses which have been advanced concerning the determinants of regression changes do not depend upon any peculiarities of the stereoscopic slant AE. The arguments against the use of bracketing procedures also have general application: exclusion of bracketing is necessary in order to disentangle interactions between SPs and rapidly dissipating sensory effects. The following discussion, then, has general application to investigations of spatial AEs which use the method of adjustment.⁹

It was argued earlier that the procedure of using objectively equal pretest and posttest SPs may not be assumed to remove SP regression effects. The procedure in which the objective target position is used as the SP is subject to similar objections and has the additional disadvantage that demand characteristics may influence the pretest judgment. Since the judged and objective pretest targets are usually similar O may not wish to make any pretest adjustment. In that case, the pretest "adjustment" in no way constitutes a control for posttest adjustment errors. E may therefore instruct O to make some adjustment with bracketing whether the stimulus appears initially set at the target or not. Here, there may be an implicit instruction that the stimulus should be set elsewhere.

Random allocation of different SPs to independent Os (for each of whom the pretest and posttest SP is the same) would not eliminate regression effects but would merely add to "individual differences," a variance component which may already be large relative to treatment effects.

The argument that it is not the "true" size of an AE which is under investigation but rather some functional relationship between the AE and selected values of an independent variable is also subject to qualification. The pilot study suggested that the

slope of the posttest regression line may change as a function of the size of the induced AE and that the magnitude of the difference between treatments could itself depend upon the values of the SPs chosen. Consider a hypothetical example of a dissipation function measured with the procedures and methods of this experiment. Curthoys would be expected to move the T-figure in the negative direction from the -12.5 deg posttest SP when the interval between stimulation and test was short. After longer intervals, the AE would be less than 12.5 deg and so the direction of adjustment from this SP would reverse. Hence, posttest regression would be different for different intervals between stimulation and test. The functional relationship argument, on the other hand, implicitly assumes that the posttest regression line is constant in slope over all treatment levels.

It may seem that one method of eliminating changes in regression from pretest to posttest would be to distribute objective SPs symmetrically around the judged target position in both pretest and posttest. However (see Introduction) this is an impossible procedure because it requires precise knowledge of the "true" magnitude of the AE under each treatment condition before the experiment is conducted. Day and Singer (1964) attempted to use such a procedure with the method of constant stimuli and were criticized by Gilbert (1967). His results indicated that the major source of variance was the shift in the positioning of the test stimuli from pretest to posttest, a result which he attributed to changes in adaptation level. However, even if it were possible to distribute SPs symmetrically about the posttest judged vertical, in the adjustment method this symmetry would exist only immediately following stimulation offset. Subsequent rapid dissipation would produce judged asymmetry of the SPs and these asymmetries would change during the course of dissipation. Thus, even were such a method practicable it would not eliminate the factors which seem to contribute to regression changes from pretest to posttest.

A common technique used to measure AEs involves the use of SPs either symmetrically distributed about or equal to the objective target position, with AEs alternately induced by equal but directionally-opposite I-figure displacements. The average of the counterbalanced measures is taken as an estimate of the "true" AE (e.g., Gibson & Radner, 1937; Morant & Harris, 1965; Singer & Day, 1965, 1966). The validity of this technique depends upon a number of assumptions. First, it assumes that equal but opposite I-figure displacements induce equal AEs. This may not always be justified: Over (1967) showed that the size of the effects differed in the case of the spatial kinaesthetic AE. A second assumption is that the posttest regression lines associated with the two directions of stimulation are parallel. If this is not the case, the average AE obtained will vary with the SP selected. A related assumption is that the objective and judged target positions are similar in the pretest. If they are markedly different, objectively symmetrical SPs will be judged asymmetrical. In that case, the effective I-figure displacements would be unequal and the AEs might not be expected to be equal in magnitude. Even if the induced AEs were not different, the effective SP asymmetry could result in regression lines of different slope. In most experiments in which equal but opposite I-figure displacements have been used the above assumptions have not been tested; in some cases, some of them have shown to be false.

CONCLUSION

This investigation has shown that some assumptions implicit in the use of adjustment in measuring spatial AEs are not justified. It has been argued that the method may produce systematically misleading results. The arguments advanced for its inadequacy in this area imply that the adjustment method may also be unsuitable as a method for measuring other induced shifts in spatial properties, for example those which occur in spatial illusions.

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Fig. 3. Pretest and posttest adjustments to the vertical, with I-figure slant always -12 deg. Broken lines connect pretest settings shown by open symbols, solid lines connect posttest settings shown by filled symbols. Ss were Curthoys (triangles) and Wenderoth (circles).

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NOTES

1. This research constituted part of a dissertation submitted by the senior author in partial fulfillment of the requirements of the degree of Master of Arts at the University of Sydney. The results were presented at the 10th Canberra Perception Symposium, in Canberra, December, 1966.
2. Address: 40 Falcon St., Crows Nest, N.S.W. Australia.
3. When the top of the frame was nearer O than the bottom, the slant was called positive; when the top was further the slant was called negative.
4. The value of $C_{.95}$ was obtained by graphical interpolation. In Table 1, A = accept H_0 , R = reject H_0 .
5. An experiment with a groups (in this case a cells) has $(a - 1)$ degrees of freedom available for orthogonal contrasts among the a means. The additional degree of freedom may be used to test an hypothesis of the form $H_0: \mu = 0$, which is orthogonal to the other $(a - 1)$ contrasts but is not itself a contrast.
6. Values of $F_{(1 - \alpha)}^a$ were obtained from Rodger (1965, Table IV).
7. Regression equations were calculated from the sums of squares associated with linear regression (Rodger, 1965, p. 60).
8. Throughout the discussion, the term "regression" refers to the regression of vertical settings on SPs.
9. Effects similar to those presented here have recently been found by us to occur with naive Os in the measurement of auditory spatial AEs.

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