On counteradaptation*

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Often adaptation to artificially altered stimulation takes place because veridical stimulation that produces the same perceptual property that is produced by the altered stimulation is also received. In these cases, an assimilation of the two perceptual processes produced by the two different stimulations (the altered and the veridical) is supposed to be responsible for the adaptation that is achieved. This hypothesis, which was formulated by Wallach and Karsh (1963), would be confirmed by demonstrating a modification of the perceptual process produced by veridical stimulation rather than the one produced by the altered stimulation. We demonstrated this by having S observe in the dark for 20 min a luminous figure that objectively expanded as it moved toward S and contracted as it moved away. But instead of testing for changes in size perception as such, we tested for a change in the relation between accommodation and convergence on the one hand and registered distance on the other. In one experiment, such a change was measured by obtaining estimates of perceived size and depth before and after the adaptation period. Highly significant changes of size and significantly greater changes of stereoscopic depth were obtained. Inasmuch as stereoscopic vision was totally absent from the adaptation conditions, the change in stereoscopic depth that was larger than the size change can only be ascribed to a change in registered distance. In another experiment, we tested for a change in distance by having S point from the side to a vertical line, before and again after the adaptation period, under conditions where only accommodation and convergence could serve as distance cues. Significant changes in the pointing distance were measured, indicating more directly a change in the relation between these oculomotor adjustments and perceived distance. We propose the term counteradaptation for such modification of a perceptual process away from veridicality.

There seem to be two kinds of perceptual adaptation, one connected with constancies and the other concerning cue evaluation. Our experiments deal with the latter kind. When spectacles or other devices are used that alter cues to some perceptual parameter, such as visual direction, verticality, distance, or depth, a modification of the psychological process, based on such an altered cue, that compensates in part or fully for the cue alteration and tends to make perception veridical again can often be demonstrated. It is this shift back to veridicality that we here call adaptation. It is a matter of course that such compensatory modification can take place only if veridical information concerned with the parameter in question reaches S. This is achieved in most cases of modified cue evaluation by means of other cues that have an effect on the same perceptual parameter and are not altered by the spectacles or devices to which S adapts. (Sometimes, but by no means in all cases, the veridical cues are produced by S's acting, such as reaching or pointing with opportunity to correct, or by his locomotion, active or passive.) In adaptation that

consists of modified cue evaluation, then, we have an altered cue and one or more veridical cues, all related to the same perceptual parameter. A precondition for this sort of adaptation, therefore, is the existence of "paired cues," that is, two or more cues, all of which determine the same parameter, and this is true of each of the four perceptual properties mentioned. Normally, each member of a cue pair operating alone should cause the same value of the parameter they determine in common.¹ But when one is altered by spectacles and a cue discrepancy results, the conditions for a possible adaptive change exist. At the beginning of the adaptation period, the altered cue produces a parameter value which is different from that caused by a veridical member of the cue pair.² Eventually a modification in the perceptual process caused by the altered cue develops such that the difference between the value that the parameter assumes as a result of the altered stimulation and the value caused by the veridical member of the cue pair is diminished. Such a process assimilation amounts to adaptation. This is the hypothesis of process assimilation first proposed by Wallach and Karsh (1963) and discussed in detail by Wallach (1968). The work to be reported here is based on this hypothesis and is meant to

support it.

The critical feature of this hypothesis is that process assimilation merely tends to diminish the results of cue discrepancy; perceptual change in the direction of veridicality is only an incidental outcome. Only if a modification occurs in the process produced by the altered cue will veridicality increase, that is, will adaptation occur. But there is no intrinsic reason why this should always be so, because, as stated, process modification tends only to diminish the difference in the outcomes of the two processes caused by the paired cues. A modification may just as well occur in the process caused by the veridical member of the pair, or in both processes. But if it occurs in the process belonging to the veridical input, process modification will cause a shift away from veridicality, since it consists in an assimilation to the nonveridical process. Because the direction of process modification is away from veridicality, we call the result of this modification counteradaptation. The possible occurrence of counteradaptation is, thus, a necessary consequence of the process assimilation hypothesis. An occurrence of counteradaptation would support this hypothesis by furnishing confirmation for one of its essential features, namely, that adaptation is caused here by cue discrepancy. That counteradaptation has, so far, not been demonstrated is due to the fact that, with one exception (Wallach, Moore, & Davidson, 1963, p. 202), no one has looked for it.³ To do so requires testing for perceptual changes in connection with cues that are not altered by the spectacles and therefore represent the environment correctly. Not much attention is usually paid to them.

The strategy for looking for counteradaptation is to select a cue (A) whose alteration by spectacles has led in the past to rapid adaptation. Then one subjects the other, the veridical member (B) of the cue pair involved in this previous adaptation experiment, to an alteration by a suitable device, while Cue A is now used veridically. In this way, the cue pair is being subjected to a discrepancy that is different in absolute terms but may be quite similar to the previous one, if the mere difference between the cues is considered only. Because, according to the hypothesis of process assimilation, only the discrepancy as such matters, a similar discrepancy should lead to a similar modification. Since in the previous adaptation experiment the process produced by Cue A was modified, the same should happen in our new experiment. But

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Cue A is here veridical, and modification of the process it produces amounts, therefore, to counteradaptation.

Our counteradaptation experiments consisted of a transformation of an earlier experiment, namely, Experiment 2 from Wallach, Frey, and Bode (1972). In their work, the evaluation of accommodation and convergence as cues to distance was modified by the use of spectacles that forced alterations of these oculomotor adjustments in equivalent amounts. In three of their experiments, the cues that functioned veridically were limited, that is, the conditions in the adaptation period were such that, out of the numerous possible cues mediating distance, only one or two were operating in the role of veridical input, and they were different ones in each experiment. In spite of such restriction of the veridical cues, rapid adaptation was obtained to glasses that caused an alteration in accommodation and convergence equivalent to additional 1.5 lens diopters and thereby decreased all distances represented by these oculomotor adjustments.⁴ Adaptation to these glasses consisted in an increase in the distances these oculomotor adjustments represented in the nervous system. Such increases in registered distance⁵ made themselves felt in an increase in perceived size and depth and an increase in distance as represented by arm movements, always under test conditions where only accommodation and convergence served as cues for distance. In Experiment 2 of Wallach, Frey, and Bode, S found himself in a dark room with only two luminous displays visible, one at either end of the room. S's task was to walk toward one and then turn around and approach the other and to continue this activity for 20 min. Two kinds of possible veridical cues were in operation here and could have been responsible for the resulting adaptation, those derived from S's walking and those arising from the growth of the retinal image of the approached display. Because of the nature of the glasses, changes in oculomotor adjustment of eyes that looked through them corresponded to a change in distance ranging from about 60 cm to about 30 cm as our Ss moved approximately from a point 600 cm distant from a display to within 55 cm of it. Where walking was concerned, the discrepancy between an oculomotor change corresponding to a distance change of 30 cm and a walking distance 18 times as large, which was actually needed to bring about this oculomotor change, may have contributed to adaptation. As to the growth of the retinal image, the

discrepancy was between (1) a change in oculomotor adjustment equivalent to a distance change that would cause doubling of image size, and (2) an actual change in image size five times as great, for it was caused by the walk from a distance of 600 cm to a distance of 55 cm from the display. The adaptation effect so produced was measured by size and depth estimates obtained before and after the adaptation period and amounted to a size increase of 25% and a depth increase of nearly 50%.

In the present experiments, to simplify matters technically, we kept S stationary and used only image size change as a potential distance cue. Our plan was, then, to manipulate image size change to make it nonveridical and to keep oculomotor adjustment normal by having S wear no glasses and yet obtain a change in the evaluation of oculomotor cues, i.e., a modified relation between accommodation and convergence on the one hand and registered distance as measured by some of its manifestations on the other. We moved, in the dark, a luminous figure toward and away from S and made it change its size in such a way as to simulate a longer motion path. As it approached S, the objective size of the figure increased to produce image size changes that would have been produced by a figure of constant size traveling over a larger distance toward S. When the figure receded, its size decreased in corresponding fashion.

Our procedure may alternatively be considered a simulation of the effect of the kind of glasses used in the experiments of Wallach, Frey, and Bode. For technical reasons, the glasses whose effect we simulated were somewhat weaker. They would, had they actually been used, have caused the eyes to increase accommodation by 1 lens diopter and convergence in an equivalent amount. The simulated motion path in our experiment ranged from 400 cm to 33.3 cm from S's eyes. If it were actually seen through the 1 diopter "near" glasses, an object at a distance of 400 cm would have been viewed with an oculomotor adjustment for 80 cm⁶ and one at 33.3 cm with an adjustment for 25 cm. Therefore, presenting to an S who does not wear such glasses an object that moves from a distance of 80 cm to a distance of 25 cm produces the same sequence of oculomotor adjustments as presenting an object moving from 400 cm to 33.3 cm to an S who wears the 1 diopter near glasses. The 80-cm to 25-cm motion path thus simulates a 400-cm to 33.3-cm path viewed through glasses, insofar as oculomotor adjustments are concerned. The shorter motion path

was actually presented in our experiment and will be referred to with the term "actual," while the 400-cm to 33.3-cm path will be called the "simulated" path.

To make the simulation complete, the size of the figure that moves on the actual path must be appropriately manipulated. It is required to produce the same sequence of retinal image sizes as the figure would yield that moves on the simulated path. The constant size of the figure that moves along the simulated path will be called the simulated size, while the various sizes of the figure that moves on the actual path will be referred to as actual sizes. They can be computed from the following equation:

actual size

$$= \frac{\text{actual distance}}{\text{simulated distance}} \cdot \text{simulated size}^7$$

So computed, the actual size of the figure at the actual distance of 80 cm is .2, and at 25 cm, it is .75 of the simulated size. Since the equation shows that actual size is a linear function of actual distance, no further sizes need be computed.

If we abandon the viewpoint of simulation and consider the actual conditions that our S will face, we find that he will be exposed to deceptive cues to distance where image size change is concerned and to veridical distance cues by the oculomotor adjustments, for he will observe without glasses. A modification of distance perception based on oculomotor adjustments that results from this exposure would therefore be a case of counteradaptation.

METHOD OF ADAPTATION

Our apparatus presented S with a luminous figure, a diamond, that grew in size when it moved toward him and shrank as it receded. It consisted of a lightbox on grooved wheels that ran on a track. Its front was a translucent sheet to which an Aubert aperture was attached. This aperture consisted of two metal sheets, of which the left one was fixed to the box, while the other one was mounted in the fashion of a sliding door and was hence horizontally movable. With their cutouts, each in the shape of a right angle, the two sheets formed a diamond-shaped opening which became larger as the sliding sheet was moved to the right and smaller when it moved to the left. The size of the diamond-shaped aperture was controlled by a third rail, a guide rail, which was fixed to the track between the other rails. A small wheel in horizontal position, whose bearing was attached to the sliding sheet with rods

Table 1
Mean Size and Depth Estimates

1 Test Distance		Counteradaptation		Walking	
		33.3 cm	66.7 cm	33.3 cm	66.7 cm
2 Objective size and depth in pyramids in cm	S	5.5	11.0	5.5	11.0
	D	2.5	10.0	2.5	10.0
3 Preexposure size and depth estimates	S	6.42	10.13	6.82	11.58
	D	6.04	11.95	6.02	12.71
4 Postexposure size and depth estimates	S	7.07	11.81	8.62	14.52
	D	7.16	15.06	9.10	18.10
5 Difference between pre- and postexposure estimates	S	.65	1.68	1.80	2.94
	D	1.12	3.11	3.08	5.39
6 Effect as increase in size and depth	S	10.11%	16.28%	27.17%	25.44%
	D	19.36%	27.98%	52.89%	43.95%

forming a right angle, rested against the guide rail from the right side. A spring that pulled the sliding sheet to the left caused the wheel to stay in contact with the guide rail, which thus controlled the position of the sliding sheet and the size of the diamond.⁸ By means of a loop of cord and a set of pulleys, a reversible motor pulled the lightbox alternately toward and away from S. Two trip switches along the track and a relay circuit reversed the motor when the lightbox had reached either end of its motion path.

Wallach and Frey (in press) had found that the presence in objects of thin lines improved size perception when only oculomotor adjustments served as cues for distance. Apparently thin lines are good targets for accurate accommodation and convergence. We therefore added a thin vertical line to our luminous diamond and, to make it an integral part of this figure, we made it its vertical diagonal. This presented a problem because the top and bottom corners of the diamond shifted to the right as it increased in size and to the left when it became smaller again. This shift was half as great as the motion of the sliding sheet. Thus the line had to move in relation to the lightbox in a horizontal direction to keep coinciding with the corners. Our solution consisted in mounting a thin coil spring under tension horizontally and symmetrically above the aperture, one end attached to the stationary sheet and the other to the sliding sheet. A black thread was tied to the center of the spring and was held in vertical position by a weight at its lower end. As the sliding sheet, and with it the right spring attachment, was displaced, the center point of the spring and the thread moved exactly half as much as the sliding sheet, and, since this was also true of the top and bottom corners of the growing or shrinking diamond, the thread, once it coincided

with these corners, remained in that position throughout.

Because the relation between the size of the diamond and its distance from S is linear, the guide rail had to be straight. The simulated size of the diamond, i.e., its diagonal, was chosen to be 25 cm. From this, its actual sizes at 80 and 25 cm from S were computed as 5 cm (.2 times 25 cm) and 18.75 cm (.75 times 25 cm), respectively, and the guide rail was fixed to the track accordingly. It formed then an angle of 14 deg with the track. S sat at the end of the track, his head in a head- and chinrest. The exact position of the headrest was adjusted for each S so that the location of the aperture at which it measured 5 cm was 80 cm from his eyes.

This arrangement, then, achieved what we set out to do: It presented S with the sequence of image sizes that a diamond of constant size, moving back and forth between the distances of 400 and 33.3 cm from S, would produce, and it caused concomitant oculomotor adjustments that would have occurred had S viewed these motions through 1 diopter near glasses. But we achieved this without any glasses, that is, under conditions where oculomotor adjustments were veridical. A change in registered distance measured after exposure to this arrangement would therefore be an instance of counteradaptation.

The conditions of counteradaptation just described were employed in two experiments which differed only in the method of testing and, in a minor way, in the criteria of S selection. Both test methods had previously been used by Wallach, Frey, and Bode.

EXPERIMENT 1

In this first experiment, size and depth estimates were obtained before

and after a 20-min-long exposure period. The test objects were wire pyramids seen against a small luminous area in an otherwise dark room under conditions where accommodation and convergence were the only distance cues available. There were two test distances, 33.3 and 66.7 cm, and the pyramids at these distances were so constructed that they produced the same image sizes and the same retinal disparities, the latter providing the only cues for perceived depth under the conditions of the tests. This required that the more distant pyramid was twice as large as the nearer one where its base and the thickness of the wire were concerned and that its depth was four times as large as that of the nearer pyramid. These differences in depth were necessary because an objective depth interval produces a disparity that is inversely proportional to the square of its distance from the eyes. S gave his estimate of the diagonal of the base of each pyramid and of its depth by means of a series of small adjustable brass rods of different lengths. Using only his sense of touch, he selected a rod and adjusted its length to fit the distance he wanted to reproduce. The order in which the two pyramids were exposed was varied but was, for a given S, the same in the pre- and postadaptation test. The size and the depth estimates, always in that order, were given for one pyramid and then for the other. Twenty Ss, selected undergraduates, participated. The following selection criteria were applied: In the preexposure test, S had to give a size estimate for the 66.7-cm-distant pyramid that was at least 1.4 times as great as that for the nearer pyramid. Also, the corresponding ratio of depth estimates had to be at least 1.7.

Results

The results of these tests are reported in the first two columns of Table 1. The mean size and depth estimates for the two pyramids after exposure to the counteradaptation conditions were larger than the corresponding mean estimates before the exposure, and the four differences were highly significant: in each of the two size tests, 18 of the 20 individual pairs of pre- and postexposure estimates showed changes in the same direction as the means, and among the 40 individual depth estimates, there was only one case in which the postexposure estimate failed to be the higher one. At each test distance, the mean proportional increase in depth was significantly greater than the mean proportional increase in size, with $p < .01$ in either case (see Line 6 in Table 1). Corresponding results had been obtained by Wallach, Frey, and

Bode, who had found increases in size and depth estimates as a result of adaptation to near glasses under conditions partly simulated in our experiment. They had concluded that the changes in size and depth brought about by adaptation had been due to an alteration in the relation between accommodation and convergence on the one hand and registered distance on the other, with the size and depth increases both the result of the change in registered distance. We can draw essentially the same conclusion from our results. Stereoscopic depth was again absent from our exposure conditions, and any change in stereoscopic depth perception must therefore have resulted from the changes in the diamond size to which our Ss had been exposed. Only a change in registered distance can conceivably mediate between these size changes of the diamond and the resulting modification of depth. Again this interpretation is supported by the fact that the effect on depth was larger than the effect on size, a result that would have to be expected if both the size and the depth increases were due to an increase in registered distance. (As stated, perceived size is proportional to the first power and perceived depth proportional to the square of registered distance.) In fact, the only reason for including size estimates in our test was to obtain such a difference between the increases in size and depth, for the size increases, as such, could conceivably have occurred as an adaptation to the changing size of the moving diamond; it is possible to interpret them as a partial compensation for the diamond's smaller objective size at the larger distances.⁹

When our results are compared with those of Experiment 2 of Wallach, Frey, and Bode, as reproduced in the last columns of Table 1, some quantitative differences emerge. In the first place, our size and depth increases were, on the average, only half as great as those obtained by Wallach, Frey, and Bode with glasses and with S walking. (These differences were significant, with $p < .01$ for size as well as for depth.) There were two material differences between their Experiment 2 and our experiment that can account for this difference. In their Experiment 2, S wore 1.5 diopter near glasses, while in the present experiment, 1 diopter near glasses were simulated. It is possible that weaker glasses would produce smaller adaptation effects. The other difference was that in Experiment 2, Ss were walking toward stationary figures and obtained kinesthetic information for their approach, while in our experiment, Ss remained

stationary, the distance change being brought about by movement of the figure. This circumstance eliminated from the exposure conditions one set of possible cues for distance change, namely, kinesthetic cues from S's walking.

The results of our experiment differed in another way from those of Experiment 2 as well as of three other experiments of Wallach, Frey, and Bode. In those experiments, the size and depth increases were proportionally about the same for the two test pyramids. In our experiment, these increases were larger for the pyramid at the 66.7-cm test distance, and this difference was significant ($p < .05$ in the case of size and $p = .05$ in the case of depth). But as far as the importance of our experiments is concerned, these quantitative differences between our results and those of Experiment 2 are of no concern.

EXPERIMENT 2

Some time after the experiment just reported had been completed, we found that adaptation to glasses which change accommodation and convergence can also be measured by having S indicate the distance of a target by pointing, and this finding was incorporated in the report by Wallach, Frey, and Bode as Experiment 3. Because the interpretation of our present experiment as a case of counteradaptation hinges on the demonstration that our exposure condition produces a change in distance perception, we repeated our experiment, replacing the size and depth estimations with the pointing test.

In this test, S was standing, with his head in a head- and chinrest, and faced in complete darkness a dimly luminous rectangle, 30 cm high and 1 cm wide. A vertical black wire .6 mm thick was stretched lengthwise over the rectangle. About 7.5 cm to the right of the wire and parallel to the median plane of S's head was a vertical panel. Its near edge was 8 cm from S's eyes, and its far edge was 60 cm beyond. S's task was to bring his right hand approximately up to eye level and some distance to the right of the wire and to point from that position with his index finger to the wire, moving his hand leftward until his finger touched the panel. While S kept his finger in place and had his eyes closed, E marked the position of the finger on a paper that was fastened to the panel and later obtained the pointing distances from these markings. Three such pointings were made before the exposure period and three after adaptation. Each group of

Mean Pointing Distances	in	Centimeters
Test distances	25	33.3
Preexposure pointing distance	25.1	34.1
Postexposure pointing distance	28.1	37.6
Proportional increase in distance	12.1%	10.8%

three pointing distances was averaged, and these values were recorded as the pre- and postadaptation pointing scores. In order to see if we would find here, too, a larger effect for a greater test distance as had been obtained in Experiment 1, the pointing tests were made with the rectangle and wire at two distances, namely at 25 cm and 33.3 cm from S's eyes. Because of the limitation inherent in the length of S's arms, we could not use the same test distances as before. Twenty selected Ss participated. A new selection criterion was used; it was concerned with the exposure period. In order to be accepted, an S had to perceive the diamond as becoming larger and smaller as it moved toward and away from him. We assumed that these size changes were an indication that accommodation and convergence furnished more precise or effective distance cues.

The results are given in Table 2. Although a good performance in the pointing test was not a selection criterion, the mean pointing distances before adaptation were in good agreement with the objective distances of the wire. (Compare Lines 1 and 2 in Table 2.) After the exposure period, the mean pointing distances for the two targets were 12.1% and 10.8% larger; these changes were highly significant ($t = 7.3$ and 5.8 , respectively). The slightly smaller adaptation effect that was measured at the larger test distance was not significantly different from the other ($p > .6$). Whereas in Experiment 1 with the size and depth estimation tests a significantly larger adaptation effect was measured at the larger test distance than at the smaller one, no such difference was found with the pointing test. But because the pairs of test distances used were not the same in the two experiments, we do not discuss this comparison. The distance of 33.3 cm, however, was used in both sets of tests, and here the results are in fair agreement. The mean proportional increase in size, which, according to Emmert's Law, is the same as a proportional increase in distance, amounted to $10.1\% \pm 4.0$, and the mean increase in pointing distance amounted to $10.8\% \pm 3.9$.

DISCUSSION

The main purpose of our experiment was to establish firmly the concept of counteradaptation and the closely related idea of cue discrepancy as a basis of perceptual adaptation. Exposure to a luminous object in the dark that grew as it moved toward S and shrank as it moved away caused changes in size perception and in stereoscopic depth perception that can only be interpreted as resulting from a change in registered distance. The same exposure also caused changes in apparent distance demonstrated by a pointing response. Since accommodation and convergence were the only distance cues available in these tests and since they operated veridically during the exposure period, our "adaptation" period resulted in a perceptual modification away from veridicality instead of one tending to reestablish veridicality. Whether, besides such counteradaptation, our exposure period also produced an adaptation we do not know because we failed to test for adaptation. In this, our experiments corresponded to most work in perceptual adaptation where hardly anyone has tested for the kind of change we call counteradaptation.

Inasmuch as the conditions of our exposure period produced abnormal changes in image size in conjunction with normal changes in accommodation and convergence, the modification in the relation between these oculomotor adjustments on the one hand and registered and apparent distance on the other must have been caused by these abnormal image size changes. Only the discrepancy between the information about distance provided by these oculomotor cues and information provided by the image size changes could have been responsible for the perceptual effects we obtained. That image size change can play this role is another result of our experiments. In Experiment 2 of Wallach, Frey, and Bode, not only change of image size but also cues of S's locomotion were in conflict with the distance cues furnished by the oculomotor adjustments, but these kinesthetic cues were absent from our experiments. Our result, however, should not be taken to mean that image size change as such can serve as a cue for distance. By itself, change of

image size is ambiguous; a given image size change may be produced by a small distance change of an object nearby or a large distance change by a far object. But if the change of image size is large compared to the change of distance implied in the oculomotor adjustments that simultaneously take place, it can still be in conflict with the distance cues derived from these oculomotor adjustments. This was the case in our exposure period where the object of changing size that was presented produced a retinal image whose size changed by a factor of 12. (It will be remembered that the objective size changes simulated an object of constant size moving between the distances of 33 and 400 cm.) Because ordinarily the shortest viewing distance is 25 cm, the smallest distance range that can accommodate a change of image size of 12 to 1 is from 25 to 300 cm. This is very different from the actual motion path of 25 to 80 cm for which oculomotor adjustments were made.¹⁰ Thus, even this shortest motion path that can accommodate the given image size changes comprised distances considerably larger than the actual distances to which oculomotor adjustments were made and provided the cue discrepancy that produced the obtained modification in the relation between oculomotor adjustment and registered distance.¹¹

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NOTES

1. This statement is not meant as a prediction always verifiable by direct tests. Different members of cue pairs may determine their parameter with different accuracy, or the processes they cause may yield more or less readily to opposing tendencies. Such opposing tendencies exist, for instance, in distance perception where, according to Gogel (1969), a specific distance tendency operates.
2. Under conditions where both the altered cue and veridical cues are present, it cannot be predicted whether or not or to what degree perceptual experience will reflect the altered parameter value, and what is experienced seems to have little bearing on subsequent adaptation. The perceptual outcome of conditions of such cue conflict is also subject to strong individual variations. For details, see Wallach (1968).
3. When they tested for modification of the process caused by the veridical cue, Wallach, Moore, and Davidson found none.
4. For a more detailed explanation of the effect of these glasses, see Wallach and Frey (1972).
5. The concept of registered distance was explained and its application demonstrated by Wallach, Frey, and Bode (1972).
6. A point 400 cm distant from the eyes is normally viewed with .25 diopter accommodation. (1 lens diopter = 1/distance measured in meters.) The glasses, by forcing an increase in oculomotor adjustments equivalent to 1 lens diopter, cause the point to be viewed with 1.25 diopters. This corresponds to a viewing distance of 80 cm.
7. The equation follows from the law of projection, $\text{image size} = c \cdot \text{object size/distance}$. Because we want to make the retinal images produced by the actual sizes at the actual distances the same as the retinal images of the simulated sizes at the simulated distances, we make $\text{actual size/actual distance} = \text{simulated size/simulated distance}$.
8. We thank Mr. Otto Hebel for designing and constructing this variable aperture.
9. In 1947, the senior author experimented with an analogous setup, but he hoped to bring about changes in size perception. When he realized that the effects he obtained could have been changes in the evaluation of accommodation and convergence as cues for distance, he lost interest. Such is the impatience of youth.
10. Even in the case of the rare S whose visual habits involve a shortest viewing distance as small as 15 cm, the smallest distance range that can accommodate the given image size changes still reaches to 180 cm.
11. This effect of image size changes implies that the nervous system attributes these changes, at least in part, to distance changes rather than to changes in object size. The often observed fact that size change of a stationary object gives rise to an apparent distance change seems to be another consequence of this tendency.

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