Adaptation to a minified image¹

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Abstract

When subjects are exposed to an optically minified image, objects at first appear diminutive. It was shown that with continued exposure a process of adaptation takes place in the direction of veridical size perception. Purely visual information is a sufficient condition and movement is not a necessary condition for such adaptation.

Introduction

What is the relationship between the specific visual angle subtended by an object (at some specific distance) and the particular impression of phenomenal size yielded by it? An object the size of an apple (at arms length) yields an image of only a few millimeters. The problem we are raising is why an image of that size yields a percept the size that it does. Must the images of objects be the size that they are for the impressions of size to be what they are? If, for the newborn infant, the entire image were magnified or minified would this yield impressions which were non-veridically too large or too small? It seems improbable that this would be the case although it is the case for an adult. Assuming the adult carries in memory some representation of the specific visual angles associated with specific size impressions, we set out to ascertain if adaptation to an optically minified image was possible.

Method

In our first experiment we required subjects to look through a lens system which reduced the size of all objects in the field by a factor of two (minification) but soon found that such a system also created the impression that objects were further away than they actually were. As a result, objects did not necessarily appear smaller, only further—the operation of the function which yields size constancy. To get around this difficulty, we made use of a convex mirror which also achieves minification but does not seem to affect apparent distance in the manner described. Objects viewed through the convex mirror do appear diminutive as one might expect, but if there is no necessary linkage between specific visual angle and specific phenomenal size, and if information is available as to the true size of objects, we should expect adaptation to occur over time. Objects seen through the mirror should more and more approach their pre-experimental phenomenal size.

The problem of how to measure such adaptation proved difficult. Size matching is ruled out because adaptation would affect standard and comparison alike. In measuring adaptation to altered orientation or displacement, the subject can be asked to judge in terms of a unique

internalized standard (such as the vertical or the straight ahead). But there is no unique size. The method devised, therefore, entailed first presenting the subject with a standard-length line which he later was to match from memory. To afford a base line against which to gauge if adaptation had occurred, the line was presented over and over and matched each time from immediate memory prior to exposure to the convex mirror. Because it is unlikely that adaptation would measurably affect the apparent size of the entire visual scene it was decided to make the test line luminous and present it in a totally dark room. In keeping with current practice, the more conservative method of measuring adaptation before and after exposure without the optical device was employed. To summarize, a 12 in line (1/16 in wide) was shown with lights on at a distance of 2 ft from the S. The line (now liminous) was then matched by the S with lights off. It was then shown again with lights on and matched again with lights off and so forth for a total of eight trials (ascending and descending order being systematically varied). Following the exposure to the convex-mirror scene, the S was again placed 2 ft from the wall and, from memory, made two more settings (one ascending, one descending) of the luminous line to equal the length seen previously with lights on. If adaptation occurred, the line, if set to the average pre-exposure length, would appear too long because shorter retinal extents than heretofore have come to signify specific phenomenal extents. Assuming the phenomenal length of the standard can be recalled fairly accurately following the exposure period (a fact established by a control group), that length should now be represented by a shorter visual angle than prior to the exposure period.

During the 30 min. exposure period the S sat at a table with his head inside a large cardboard tube which permitted him to see only the scene reflected by the 12 in diameter convex mirror (48 in radius of curvature) placed at the opposite end of the tube. Through the mirror he saw the top of the table on which were placed various objects and he could also see his hands and arms, his head (through the tube) and portions of his trunk. The interior of the tube was lined with black felt and pains were taken to prevent illumination from reaching it. For objects located about 2 ft from the mirror, visual images of about half size were formed at a distance of about 1 ft beyond the plane of the mirror. In all experiments the objects on the table consisted of playing cards, pencil and paper, and checker board

Table 1. Pre and Post-Exposure Judgments of Line Length in Inches

Experiment	N	(1) Mean of all 8 pre-adapt. settings	(2) Range	(3) Mean of last 2 pre-adapt. settings	(4) Range	(5) Mean of 2 post-adapt. settings	(6) Range	(7) Diff. Col. (1-5)	(8) Diff. Col. (3-5)
1	9	10.71	3.20	10.57	1.14	10.68	1.25	-.03	+.11
2	15	11.51	3.85	11.57	1.83	10.22	1.47	-1.29	-1.35
3	10	10.85	2.37	10.97	1.35	9.86	.92	-.99	-1.11
4	10	12.01	2.56	11.80	.97	10.96	.71	-1.04	-.85

with checkers. In all but the third experiment (in which movement was not permitted) the S engaged successively for 1/3 of the time in solitary, drawing pictures, and playing checkers. In the third experiment the S merely inspected these objects for the same length of time. In all experiments but the third the S never withdrew his head from the tube until the time of the post-exposure test. In the third experiment he withdrew briefly every 10 min. in order to be allowed to move around for a few seconds but the room was totally dark at that time. The Ss in all experiments were 16 to 18 yr. old high school students, primarily males, paid for participating but completely naive as to the purpose of the experiment.

Results

Experiment 1: Control. In the first experiment, a plane mirror was substituted for the convex mirror but otherwise the procedure was as described above. The results for nine Ss are given in the first row of Table 1. The mean of all eight pre-adaptation judgments is given as is the mean of only the last two such judgments. Mean differences between pre- and post-exposure judgments are calculated with respect to both of these values. Several facts stand out in these results, namely there is a constant error which suggests that the luminous line appeared longer than the 12 in standard seen in the light (hence in all experiments the pre-adaptation mean is less than 12 in), variability of judgments is low (range) considering the usual spread obtained between ascending and descending trials, and the ability to remember the standard length after 30 min. is gratifyingly good. There is no change in the judged length of the line following exposure to the plane mirror.

Experiment 2: Minified image. In the second experiment we sought to obtain adaptation to the minified image provided by the convex mirror. The subject was free to move his arms in carrying out the various activities assigned. His head was free to move but his chin rested on a bar at the bottom of the tube and hence did not move very much. As is shown in the second row of Table 1, significant adaptation was obtained. The great majority of the 15 Ss set the line appreciably smaller after exposure to the mirrored scene than before it. Against the base line of the average pre-adaptation settings, we calculate adaptation to be 23% of total adaptation, assuming the latter would require a reduction to half the pre-adaptation setting.

Experiment 3: No movement. In view of the current interest in the role of movement in adaptation experiments, a variation was included in which movement of visible portions of the body was not permitted. The S rested his arms on the table but they remained stationary for the 30 min. period. He was also instructed to keep his chin stationary throughout the period and Ss that failed to comply were eliminated. We are assuming no one would wish to argue that slight muscular tremors could play a causal role in adaptation to size. The results for 10 Ss are shown in the third row of Table 1. Significant adaptation was obtained, of a magnitude not appreciably different from that obtained when movement was permitted.

Experiment 4: Ten minute exposure. There were three changes in procedure in this experiment from that used in Experiment 2. (1) The exposure period was reduced to 10 min. (2) The S himself adjusted the luminous line by means of a knob (not visible of course). (3) All objects were presented on the table throughout although for one-third of the time S successively engaged in each of the three activities. The results for 10 Ss shown in the fourth row of Table 1 indicate that significant adaptation occurs.

Discussion

The findings suggest that we learn the size-signification of a specific visual angle (at any fixed distance). How is this information given? We believe the impression of a specific phenomenal size is a function of the size of an object relative to that of all other objects including the phenomenal self. A consistent transformation of the entire image such as occurs in magnification or minification does not alter the size-relation of retinal images to one another. Hence the same information about size is given. Adaptation consists in undoing existing associations between specific visual angles and specific phenomenal-size impressions which are carried in memory and substituting new associations. We have shown that purely visual information is a sufficient condition to establish such new associations. Movement is not a necessary condition. Whether movement is a sufficient condition is not known at this time.

Note

1. This research was supported by grant No. GB-918 from the National Science Foundation.