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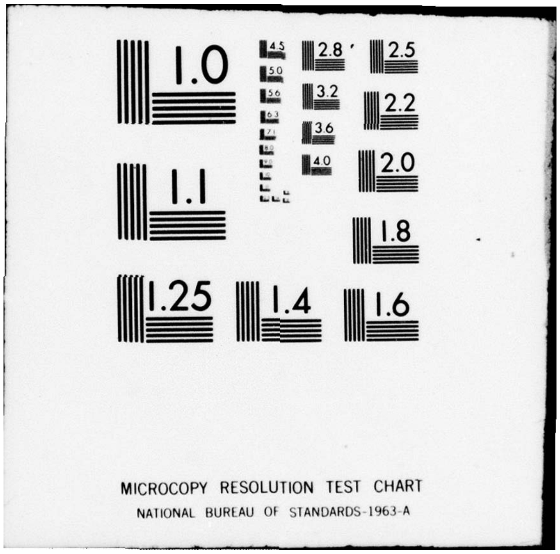
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Effects of Optical Magnification on the Perception of Displayed Orientation

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Two experiments are reported that assess distortions of perceived surface orientation as a result of geometric distortions of two-dimensional spatial displays. Optical magnification (defined in terms of the ratio of actual to geometrically correct viewing distance) greatly affected perception of surface orientation when no consistent information was available for the magnitude of spatial distortion. However, when magnification was caused by (and perfectly correlated with) viewing distance, observers were able to totally compensate

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for or discount the effects of the geometric distortion of space. Compensation for spatial distortion is dependent on the means by which such distortions are produced. Implications of these results and the compensation process are discussed.

An important problem in the understanding of visual perception involves the representational nature of graphic displays of space. Ideally, an observer's perception while viewing a two-dimensional display would be identical to perceptions while viewing the actual objects or scenes depicted. In principle, this should be easily accomplished. A display can project nearly the same geometric array to a single, stationary eye as would be produced by the scene it represents.

However, geometric isomorphism does not assure perceptual equivalence of graphic displays and the scenes they represent. Further, displays must often be viewed from various points, and not solely from the unique viewing point at which pictorial and environmental arrays are identical. Under such viewing conditions, represented space is geometrically transformed or "distorted" if the display is viewed from the incorrect point. More specifically, we define a "virtual space" as the geographical layout which could have generated a particular pictorial array. At the correct viewing point (the center of projection for the display), this virtual space is isomorphic with the environment depicted. For every other possible viewing point, there is a different, corresponding virtual space.

In this paper, we address the question of what relationships exist between the geometric structure of these virtual spaces and the corresponding perceptions of observers viewing a display. In other places (Farber and Rosinski, 1978; Rosinski and Farber, in press), we have shown that all distortions of virtual space caused by shifts of viewing point can be geometrically described by two linear transformations: a magnification which occurs as the viewing point is displaced normal to the display surface, and a shear which occurs with a displacement of the viewing point parallel to the display surface.

This paper examines the effects of optical magnification on the perception of three-dimensional spatial orientation. Such optical magnifications (and minifications) occur when the display is viewed from a point too close (or too far) away relative to the center of projection. As was demonstrated in our earlier publication, magnification results in a virtual space which is equivalent to an affine transformation (one in which colinearity and parallelism of lines is not changed) which compresses the original virtual space. If m is defined as the magnification ratio (distance from display to center of projection/distance from display to viewing point), then the effects of the compression of virtual space are completely summarized by the statement that all depth values are multiplied by $1/m$. Relative size, shape, slant, and all properties that depend on relative distance will be affected. For example, in such a compressed virtual space, surface slants are shifted toward the frontal plane: a slant of θ is transformed into θ' such that $\tan \theta = m \tan \theta$. Slants near the frontal and near the horizontal are relatively less affected than are other slants. The orientation of the horizontal and vertical planes are not affected at all. For example, under a 2 power magnification, a slant of 89° (1.553 rad) is transformed into 89.5° (1.562 rad); a slant of 45° (0.785 rad) becomes 63.43° (1.107 rad); and a 1° (0.017 rad) slant becomes 1.99° (0.034 rad).

These effects describe the transformed structure of the virtual space. If perception involved a perfect psycho-physical correspondence between the geometry of the optic array and the accompanying percept, these structural changes would also describe perceptual changes. However, perception is not simply determined by geometry, and the specific effects of such transformations on perception are, largely, unknown.

The purpose of the present studies was to determine how observers' perceptions of space are affected by such distortions, and how perceptual accuracy can be optimized. Two kinds of experiments were conducted. In the first, observers were stationary and the display's center of projection was manipulated over conditions. This corresponds to situations in which magnifications or minifications of displayed space are induced independent of the observer's position. The second experiment evaluated the effects of magnifications and minifications caused by changes in the location of the viewing point. Since some theorists (e.g., Pirenne, 1970) have speculated that observers may be able to discount the effects of distortions produced in this way, this speculation was directly tested.

Experiment 1

Seven magnifications were induced by varying the location of the display's center of projection while keeping the location of the viewing point constant. The geometrical (projective) effects of magnifications of 1, 2, 3, and 4X on slant are depicted in Figure 1. Note that as the equation described above indicates, surfaces become projectively more frontal as magnification ratio increases. The geometric effects of fractional magnification (minification) are depicted in Figure 2; slants are projectively more horizontal as magnification decreases.

Figure 1

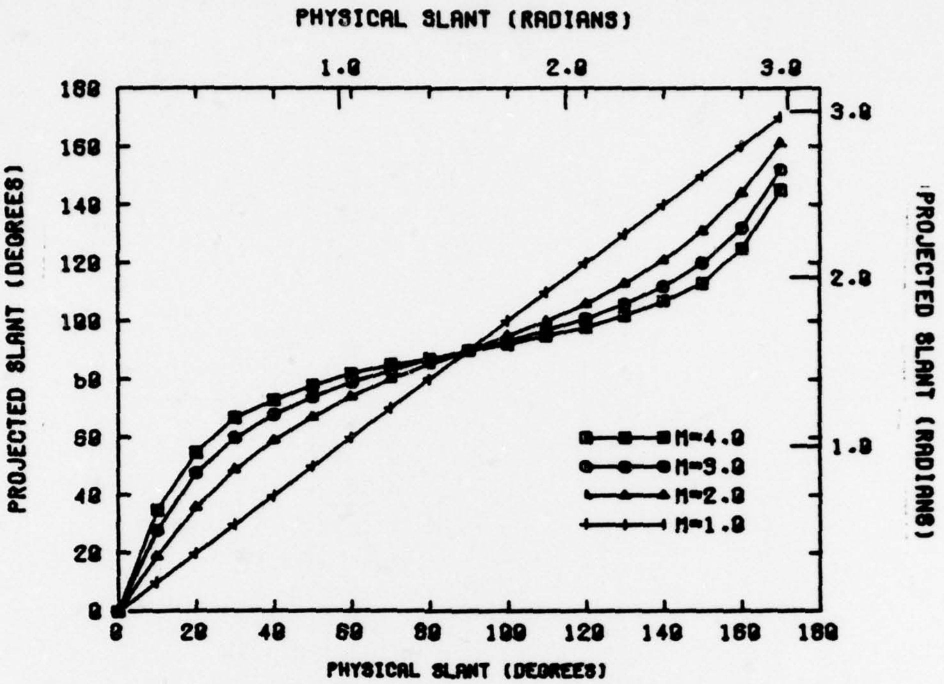
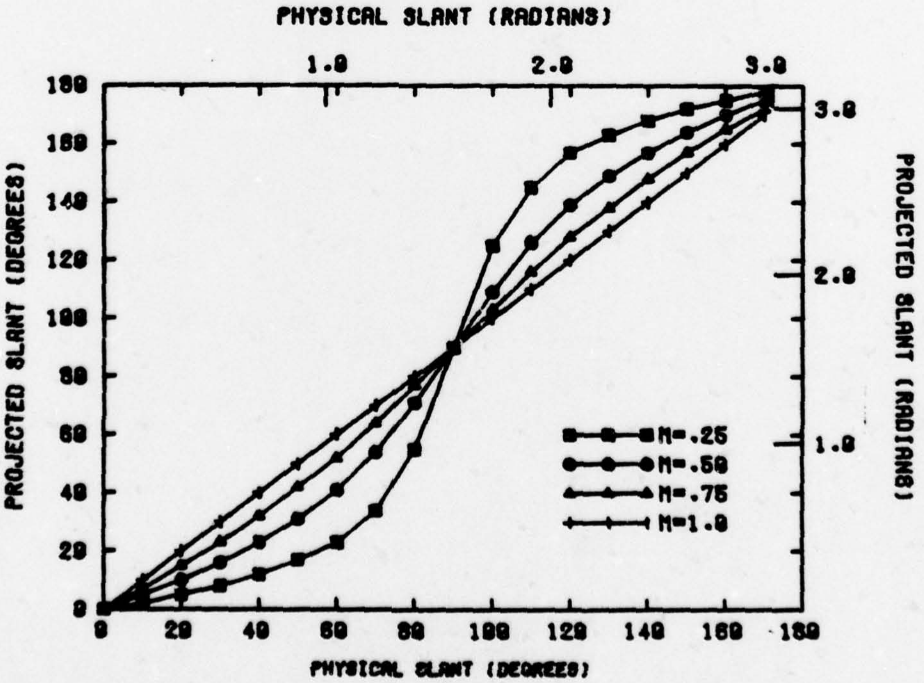


Figure 2



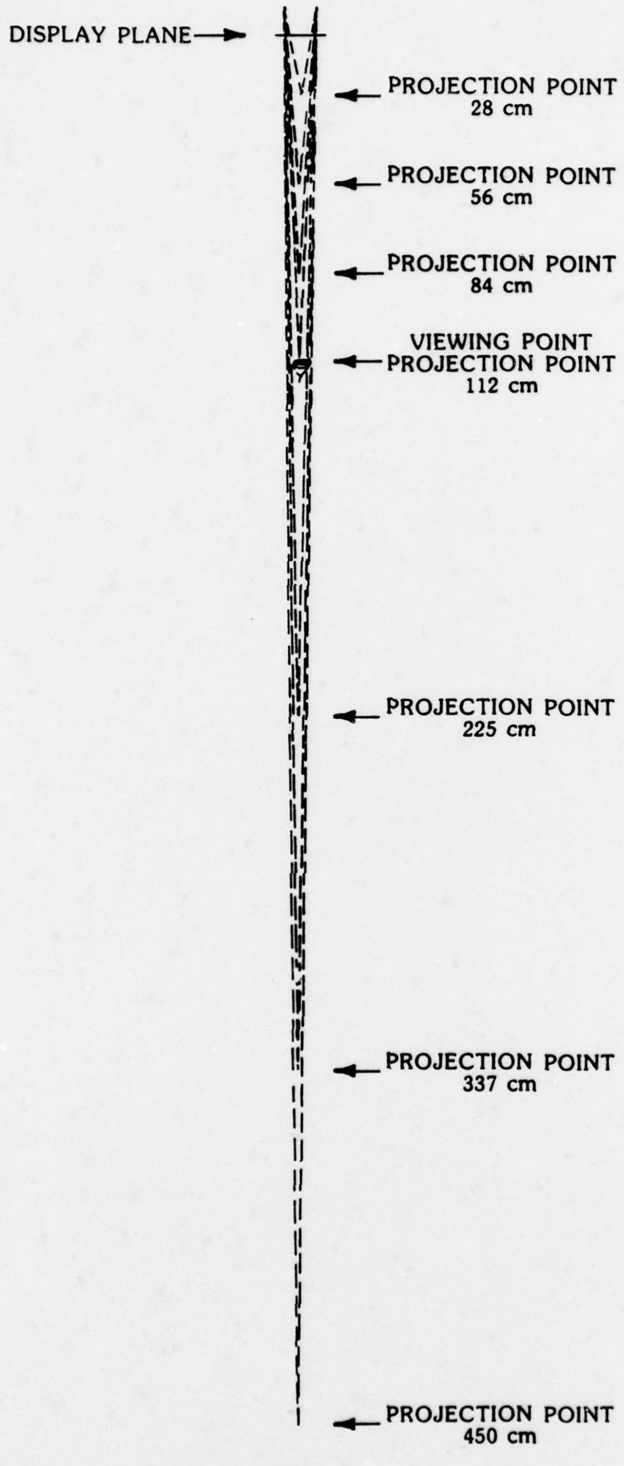
Method

Observers. Six paid, adult volunteers (3 men, 3 women) served as participants in the research. All individuals had visual acuity of 20/40 (corrected) or better, and those who normally wore corrective lenses did so during the experiment. Participants made 18 perceptual judgments in each of four blocks per condition, in fourteen conditions, for a total of 1,008 judgments per observer.

Apparatus. The stimuli were computer-generated graphics displayed on a CRT. A square surface (11.1 X 11.1 cm) was divided into an 8 X 8 lattice to maximize texture gradient information for orientation. It was defined logically at 36 different orientations, which varied from 0 (0 rad) to 170 degrees (2.966 rad) in 10 degree (0.174 rad) increments relative to either a horizontal or vertical plane bisecting the center of the screen. Thus there were 18 rotations around the X-axis, and 18 around the Y-axis. In all cases, the axis of rotation bisected both the surface and the screen, and was logically defined 7.6 cm behind the screen.

Across conditions, these surfaces were displayed such that the geometrical center of projection of the screen images was located at 28, 56, 84, 112, 225, 337, or 450 cm from the screen. The viewing and display conditions are schematically depicted in Figure 3. The experimental participants viewed the screen binocularly, with their head held by an ophthalmic chin stand, from a viewing point 112 cm from the screen. Such viewing conditions result in magnifications of 0.25, 0.50, 0.75, 1.0, 2.0, 3.0, and 4.0.

Figure 3


DISPLAY PLANE
PROJECTION POINT 28 cm
PROJECTION POINT 56 cm
PROJECTION POINT 84 cm
VIEWING POINT
PROJECTION POINT 112 cm
PROJECTION POINT 225 cm
PROJECTION POINT 337 cm
PROJECTION POINT 450 cm

The conduct of the experiment was computer controlled. A program at the command monitor level controlled the order of conditions for each observer. The experimental program presented the displays in random order, controlled the number of presentations, and recorded responses.

Procedure. When each observer logged on to the laboratory computer system, he/she was automatically connected to the experimental control program. The appropriate condition was selected, instructions displayed, and a sample stimulus (not used in the experiment proper) was displayed. After an identifying number was entered by the observer, the stimuli were sequentially presented. In all conditions, the observers were to judge the orientation of the surface, in degrees, using the following convention: frontal surfaces were to be labeled 90, and numbers less than 90 were to be used if the top (or left side) was further away than the bottom. Judgments were entered on a keyboard connected to the laboratory computer. When the return key was pressed, the stimulus was removed, a mask of 200 connected randomly oriented lines was displayed for 1/60 sec to reduce screen persistence effects, and the next stimulus (randomly determined) was presented. Thus the rate of presentation was totally controlled by the observer. To eliminate speed-accuracy tradeoff effects, judgments requiring longer than 6 sec were not recorded, but that stimulus was recycled within the session. At any time during the experiment, observers could cease participation by pressing an escape key.

Results and discussion

The mean judged orientation of the lattices as a function of physical orientation is presented in Figures 4 and 5. The degree of magnification is treated as a parameter. The function for m = 1.0 (no magnification) is included in both figures as a comparison. The data were analyzed in a 6 (observer) X 7 (magnification) X 2 (X-Y judgment) X 4 (block) X 18 (slant) complete factorial analysis of variance.

There was a significant effect of the defined surface slant on judgment, $\underline{F}$ (17,85) = 284.54, $\underline{p} < .01$. Such an effect merely indicates that some general relationships exist between the physical orientation of surface and judged orientation when such judgments are based on texture gradient information. The various magnifications used in the experiment all resulted in a similar mean orientation close to 90 degrees (1.57 rad). It is to be expected, then, based on the selection of stimulus conditions that there would be no mean effect of magnification. Indeed, this expectation is supported since there were no significant differences among the 7 magnification conditions, $\underline{F}$ (6,30) = 1.22, $\underline{p} > .05$.

On both theoretical and empirical grounds, the effects of slant and magnification are most profitably examined in light of the significant slant by magnification interaction, $\underline{F}$ (102,510) = 2.74, $\underline{p} < .01$. Magnification or minification of a spatial display alters the geometric information specifying surface orientation. Under the conditions used in the present study, several families of new virtual spaces are created. In each, virtual orientation of the stimulus surface varies with degree of magnification.

If perceived orientation were totally determined by the geometric information available to an observer, judged orientation and virtual orientation should be isomorphic within the limits imposed by observer constant error. Such a result was reported by Purdy (1960) in a somewhat analogous experiment. After the effects of constant error of

Figure 4

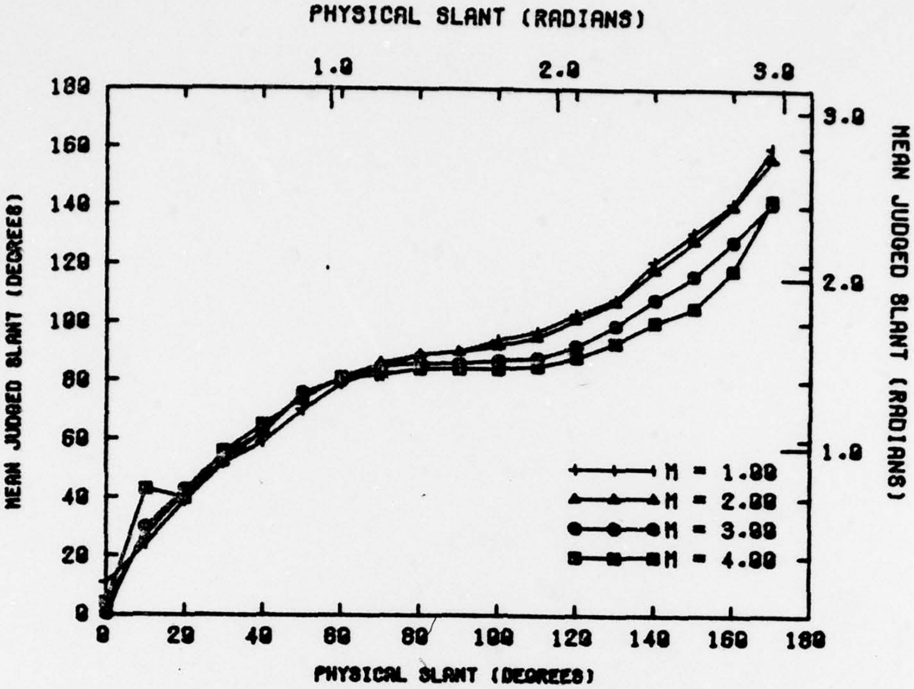
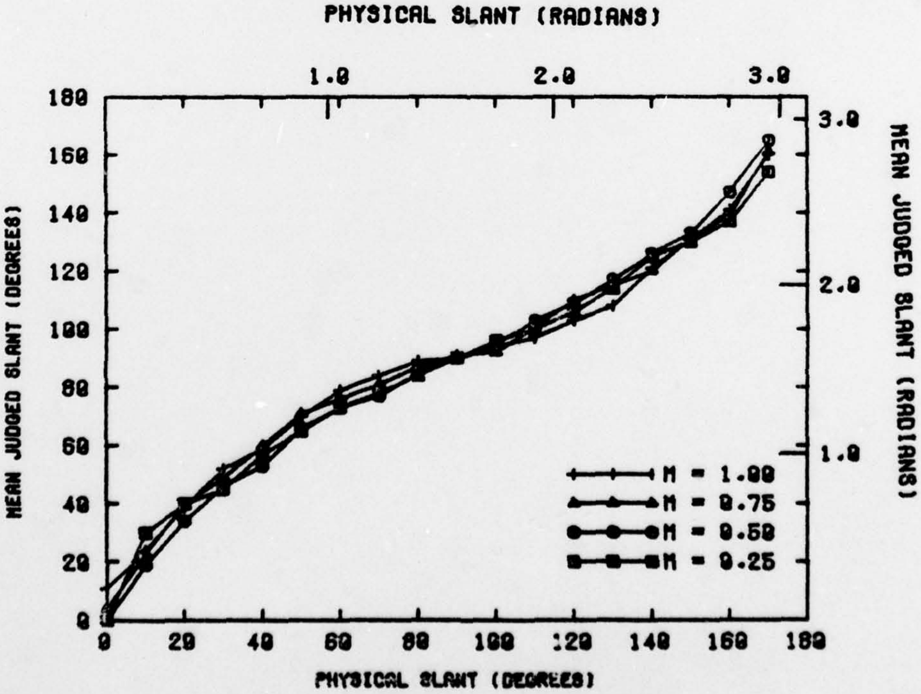


Figure 5



judgment were removed, Purdy found that the observers' judgments differed from the geometric predictions (based on the transformation of virtual space) by only 1.05 degrees (0.018 rad). The results of the Purdy experiment and the virtual isomorphism between the geometry of a display and perception have had far reaching effects. Purdy is often cited as an initial contributor to an information-based theory of perception, and his work has been taken as a demonstration of the sufficiency of geometrical information for spatial displays.

The alternate, diametrically opposite result would be that perceived orientation is not related to virtual space. It would, of course, be difficult to conceive of a perceptual system unaffected by its sensory input; such a result is unlikely in the present experiment for reasons discussed later.

Neither of these two simple alternatives appears correct. First the existence of the projection condition by slant interaction demonstrate that the geometric distortions of virtual space induced by magnification strongly affect perceived orientation. In the virtual space, surface slants are shifted increasingly toward the frontal with increasing magnification. As can be seen in Figures 4 and 5, exactly this tendency is exhibited in the data. Thus if compressions of virtual space are created by altering the center of projection (the geometrically correct viewing point) relative to a fixed actual viewing point, distortions of perception result.

However, the present experiment finds no evidence of psychophysical isomorphism between visual information and perception. In spite of the fact that our methods were similar to Purdy's in all major respects, we are unable to replicate his findings. The sufficiency of optical information in determining perception is not demonstrated in the present data. Consistent and substantial deviations from psychophysical correspondence occur throughout.

Least squares regression analysis for each of the magnification conditions revealed that the best fit for each involved significant cubic terms, p's $< .01$. The coefficients and intercepts for these functions are presented in Table 1. It can be noted both from Figures 4 and 5, and from Table 1, that magnification compresses perceived space, but that minification does not dilate perceived space. The perception of orientation is not shifted away from the frontal as in the virtual orientation of the surface.

The specific relationships between judged and physical orientation, and the lack of complete correspondence with the virtual space can be seen by comparing the geometric prediction and actual data. In the virtual space, the relationship between judged and physical orientation is linear with slope of 1.0 for the $m = 1.0$ condition. As magnification deviates from 1.0, the relations between virtual and physical space become increasingly nonlinear.

The data do not demonstrate these trends. Although all magnification conditions give rise to significant nonlinear components, the deviation from linearity is least for the $m = 0.25$ condition and greatest for the $m = 4.0$ condition. For $m = 0.25$ a linear relationship of $Y = .75X + 20.9$ accounts for 97% of the total variance. For the $m = 4.0$ condition, the linear relationship $Y = .53X + 33.9$ accounts only for 85%. Although judgment is substantially affected by the virtual surface orientation, the accuracy was greatest for the minification condition of $m = 0.25$.

Table 1

The Coefficients and Intercepts Describing the Best Fit Cubic Equations for the Seven Magnification Conditions Used in Experiment 1

Magnification Ratios (m)	Regression Coefficients 1st degree	 2nd degree	 3rd degree	Intercept
0.25	1.72323	-0.01305	0.00005	6.49123
0.50	1.87991	-0.01483	0.00006	0.84211
0.75	1.98412	-0.01698	0.00006	4.63158
1.0	1.96938	-0.01779	0.00007	7.83041
2.0	2.27899	-0.02207	0.00008	4.36842
3.0	2.43000	-0.02479	0.00009	3.11111
4.0	2.35913	-0.02556	0.00010	8.60234

One puzzling question involves the inability to replicate Purdy's early finding that judged orientation was in almost total correspondence with virtual orientation. Although there were procedural differences between this study and that of Purdy, we suggest that the present data capture the true shape of the underlying perceptual functions, and the discrepancy with other data results from sampling problems. In this experiment, we collected 24 judgments of 36 surface orientation in 7 magnification conditions for a total of 6048 data points. Purdy, on the other hand, used only four surface orientations and 2 magnification conditions. His results are valid, and are consistent with ours within this small stimulus range. At other magnifications and slants, the correspondence between judgment and virtual orientation breaks down.

The discrepancy between judged and virtual orientation is greatest for the fractional magnifications and decreases with increasing optical magnification. Thus the $m = 4.0$ condition is in close correspondence with the virtual orientation while $m = 0.25$ deviates greatly. We suggest that these results may be the effect of a perceptual conflict induced by two-dimensional presentation. Monocular information generated by the perspective gradient from the surface specified a particular orientation. Binocular, accommodative, and convergent information specified a frontal display plane. Magnification causes the virtual surface to be more frontal. Therefore, for $m = 2.0$, $m = 3.0$, $m = 4.0$ there is relatively less conflict between monocular surface orientation and binocular display plane orientation. However, minification causes virtual orientation to be shifted away from the frontal. Therefore for $m < 1.0$, there is greater discrepancy between monocular and binocular cues. The judgments for $m > 1.0$ conditions corresponds with virtual space; judgments for $m < 1.0$ appear to be a compromise between the perspective orientation of the surface and the frontal orientation of the screen.

Experiment 2

The results of the preceding experiment demonstrate that although a perceptual compromise may occur when monocular and binocular information conflict, there is some correspondence between perceived orientation and the geometry of virtual space. Magnification results in a compression of both perceived and virtual space. There is an apparent conflict between these data and a commonly held view regarding the nature of spatial displays. Both in computer science (cf. Newman and Sproull, 1973), and in psychology (cf. Pirenne, 1970), it has been argued that optical distortion arising from magnification has little or no effect on perception. It has, in fact, been hypothesized that there exists an active perceptual compensation process that can eliminate or discount optically induced distortions of virtual space (Rosinski and Farber, in press).

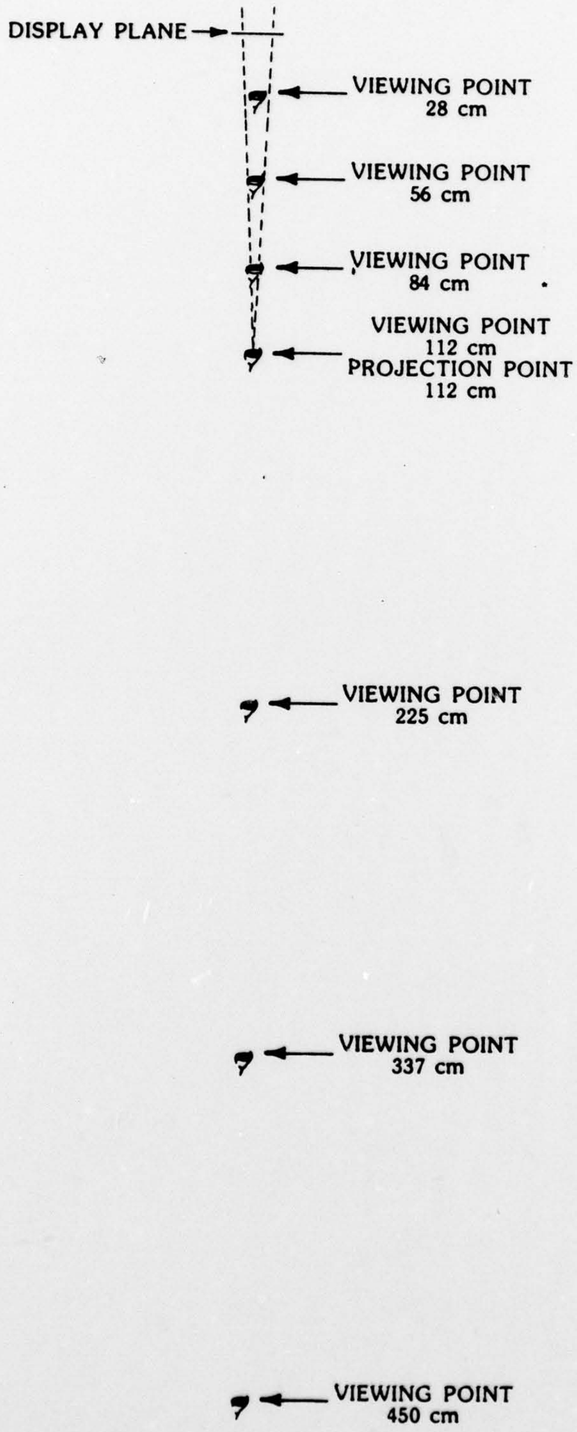
Part of the discrepancy regarding the perceptual effects to be expected from optical magnification results from the fact that there are two optically equivalent, but procedurally distinct ways of inducing a magnification. M, the magnification, is the ratio of the distance of the actual viewing point relative to the distance of the correct viewing point. With a constant location of viewing point, and changing center of projection (as in Experiment 1) magnifications are induced; the degree or existence of these magnifications can not be determined perceptually by an observer. If the center of projection is constant, and the location of the viewing point is changed an equivalent set of magnifications occur. In this circumstance, amount of magnification is perfectly correlated with viewing distance.

If space perception were simply determined by the nature of virtual space, optical magnification would affect performance regardless of the procedure used to create the magnification. If, on the other hand, a perceptual compensation process exists, it should moderate the effects of optical magnification when magnification is caused by changes in viewing point. To evaluate the compensation hypothesis, Experiment 2 determined the effect of optical magnification on perceived orientation when the magnification was created by manipulating the location of the viewing point.

Method

All details of method and procedure in this experiment were identical to those in Experiment 1 with one exception. In this study the center of projection remained at 112 cm away from the screen in all conditions. Optical magnifications were created by having the observers observe from distances of 28, 56, 84, 112, 225, 337, 450 cm from the screen. Use of these viewing distances resulted in magnifications of 0.25, 0.33, 0.50, 1.0, 1.33, 2.0, and 4.0. Viewing conditions are schematically depicted in Figure 6.

Figure 6


DISPLAY PLANE
VIEWING POINT
28 cm
VIEWING POINT
56 cm
VIEWING POINT
84 cm
VIEWING POINT
112 cm
PROJECTION POINT
112 cm
VIEWING POINT
225 cm
VIEWING POINT
337 cm
VIEWING POINT
450 cm

Results and Discussion

The mean judged orientation of the lattices as a function of physical orientation for this experiment is presented in Figures 7 and 8. Once again the degree of magnification is treated as a parameter, and the curve for the m = 1.0 (no magnification) condition is included in both figures as a comparison. As in the preceding experiment the data were analyzed in a 5-factor (6 X 7 X 2 X 4 X 18) analysis of variance.

As is to be expected, there was a strong relationship between the physical slant of the lattice and the judged slant, F (17.85) = 150.50, $p \leq .01$. As physical slant increased from 0 to 170 degrees (0 to 2.966 rad) judged slant increased monotonically. The remarkable fact about the data presented in Figures 7 and 8 is that projection condition had almost no effect at all on perceived orientation. Although the interaction between orientation and magnification condition was statistically significant, F (102,510) = 1.47, $p < .01$, any differences among conditions were extremely small in absolute terms. As can be seen in Figures 7 and 8, the range of condition means for any single orientation never exceeded 6 degrees (0.104 rad) and in most cases the condition means lie within 2-3 degrees (0.034-0.05 rad). The statistical significance is due to the fact that these slight variations in mean judgment are sufficient for significance given the statistical power of the analysis, and because there seems to be about 2 degrees (0.034 rad) more variability in the minification conditions (Figure 7) than in the magnification conditions.

In spite of this small effect, the most important finding of the present study is that the functions for the seven magnification conditions are almost co-linear. Although the distortions induced by magnification

Figure 7

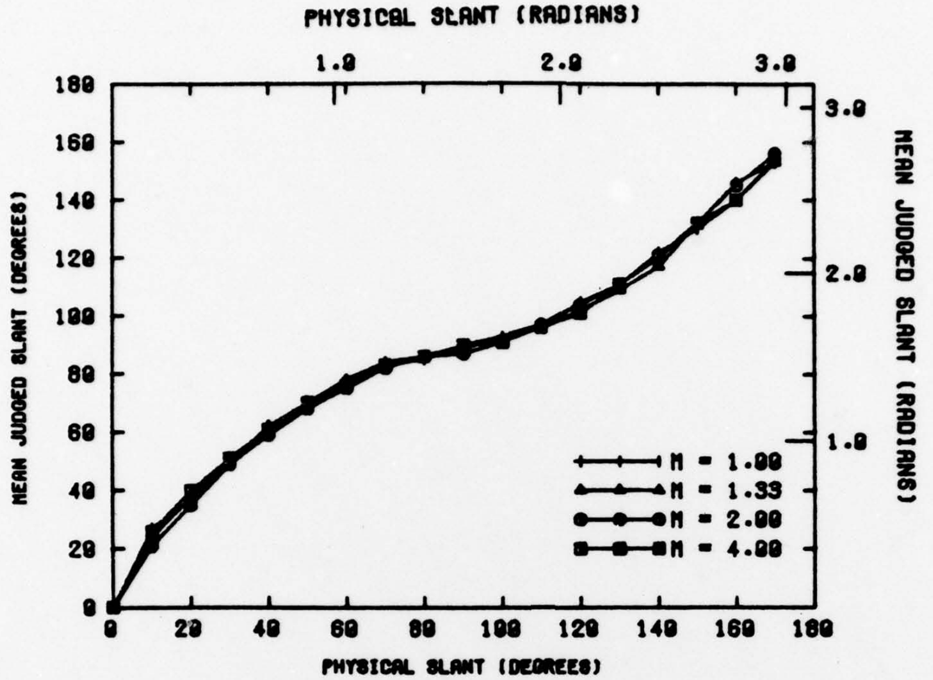
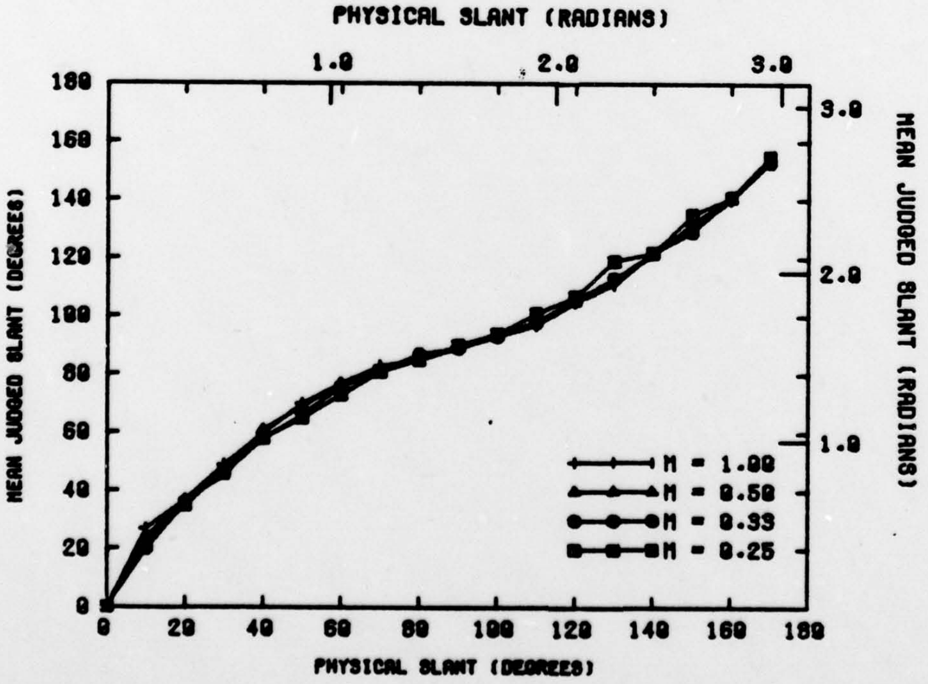


Figure 8



change the virtual slant by as much as 70 degrees (1.22 rad) among magnification conditions for certain slants, the judged orientations varied only by about 2-3 degrees (0.034-0.05 rad). The similarity of functions can also be seen in a comparison of the best fit equations for these functions. For all the functions, almost all the variance is accounted for by the cubic equations described in Table 2.

Both Figures 7 and 8 and Table 2 show that regardless of the degree of magnification, the functions relating judged and physical slant are highly similar. These data, then, demonstrate that observers can compensate almost completely for the magnifications induced by altering the location of the display viewing point. Since perceived orientation is not in correspondence with the virtual space, these results demonstrate that visual information for space is not a sufficient basis for perception. In addition to registration of simple texture gradient information, for orientation, a second mechanism is involved which is able to discount the distorting effects of magnification and result in the perception of actual rather than virtual space.

Such a compensation mechanism is evidenced only when magnificaiton is involved by change in viewing distance. When the viewing distance is constant, and magnification is created by varying the location of the center of projection for the display (as in Experiment 1), no compensation is evident, and judgments are substantially affected by changes in the geometric projection.

The implication of these facts is that compensation is based on the information available for the location of the viewing point. When magnification is perfectly correlated with viewing distance, the deviation of

Table 2

The Coefficients and Intercepts Describing the Best Fit Cubic Equations for the Seven Magnification Conditions in Experiment 2

Magnification Ratio (m)	Regression Coefficients			Intercepts
	1st degree	2nd degree	3rd degree	
0.25	1.8412	-0.01405	0.00005	2.62573
0.33	1.9731	-0.01627	0.00006	0.92398
0.5	2.22051	-0.01722	0.00006	2.16374
1.0	2.03696	-0.01762	0.00006	3.29825
1.33	2.18419	-0.01993	0.00007	1.69591
2.0	2.08627	-0.01842	0.00007	0.84211
4.0	2.10015	-0.01917	0.00007	4.00585

this actual viewing distance from some assumed correct viewing point provides a basis for pictorial compensation. This conclusion is further strengthened by considering the results plotted in Figures 7 and 8. For each magnification condition, the amount of distortion varies. Yet, the functions depicted in these figures are virtually superimposed. Thus, the amount of compensation is modulated over condition. This modulation of pictorial compensation is affected by display plane distance. However, the degree of magnification involves the descrepancy between actual and correct viewing point. Consequently, the magnification can only be inferred from actual viewing distance if some internal standard, or set point, for correct viewing distance exists (see also Rosinski, Mulholland, Degelman, and Farber, ref. note 1).

Of course, if such an assumed correct point exists for a spatial display it is important to find what its location is, and how this correct point is determined by the observer. The results depicted in Figures 7 and 8 all approximate the same function. The shape of this curve is one geometrically expected for a 2.0 power magnification (cf. Figures 3 and 6). Thus, the actual judgments after the perceptual system has discounted the effects of distortion result in performance that would be ideally expected under a two power magnification. Since the actual correct center of projection was at 112 cm from the display, such judgments would result if the assumed correct point were at 56 cm. Although the present experiments were not designed to prove that an assumed correct viewing point existed, the data suggest the conclusion that such an assumed correct point exists, and in the present situation is located around 56 cm from the screen.

The location of the assumed correct point must be based on conditions of pictorial presentation. In the present instance, this location (56 cm) is equivalent to twice the height of the display screen. An intriguing aspect of this fact is that this relationship is involved in optimal viewing of other graphic displays. Traditionally, for reasons of realism, photographs are printed and cropped so that their height is 1/2 the expected viewing distance. In addition, with conventional raster TV displays, the signal to noise ratio is highest (and therefore the image is clearest) at a viewing distance of twice the height of the screen (see Cohen, Carlson & Cody, ref. note 2).

Based on the conjunction of these several findings, it is proposed that the ability to compensate for or to discount the effects of geometric distortion is based upon an active perceptual process involving a comparison of the actual viewing distance with an assumed correct viewing distance. The location of this assumed correct point may be related to simple physical characteristics of displays and display image quality.

SUMMARY

1. Viewing a spatial display from a point nearer or farther than the geometrically correct center of projection results in distortions of virtual space that cause slanted surfaces which are more nearly frontal (for magnification) or more nearly perpendicular to the frontal (for minification).
2. If such distortions are caused by moving the geometric center of projection while keeping viewing location constant, perceived surface

orientation is affected. With magnification, perceived orientation is shifted toward the frontal. However, minification does not result in the opposite shift in judgment. Rather, with increasing minification judgment becomes more veridical. We suggest this is the result of the conflict between texture gradient information for the virtual surface and binocular and accommodative information for the display plane itself.

3. When distortions are induced by moving the location of the viewing point (so that viewing distance and degree of magnification are perfectly correlated), the geometric distortions have no effect on perception. These data provide the first quantitative demonstration of total compensation for spatial distortion.
4. We suggest that this discounting or compensation process is based on the difference between the actual viewing point and an assumed correct viewing point. The location of this assumed point may be based on characteristics of pictorial viewing.

REFERENCES

Farber, J. & Rosinski, R. R. Geometric transformations of pictured space. Perception, 1978, 7, 269-282.

Newman, W. M. & Sproull, R. F. Principles of interactive computer graphics, New York: McGraw-Hill, 1973.

Pirenne, M. H. Optics, painting & photography, London: Cambridge University Press, 1970.

Purdy, W. C., The hypothesis of psychophysical correspondence in space perception, Ithaca, NY: General Electric Advanced Electronics Center, September 1960. (NTIS No. R60ELC56).

Rosinski, R. R. & Farber, J. Compensation for viewing point in the perception of pictured space. In M. Hagen (Ed.) The psychology of pictorial representation. New York: Academic Press, in press.

Reference Notes

1. Rosinski, R. R., Mulholland, T., Degelman, D., & Farber, J. Picture perception: an analysis of visual compensation. Manuscript submitted for publication.

2. Cohen, R. W., Carlson, C. R., & Cody, G. S. Image descriptors for displays. (Technical Report ONR-CR213-120-2). Princeton, NJ: Radio Corporations of America, 1976.