The role of gradients of binocular disparity in Gibson's theory of space perception*

COLIN V. NEWMAN
University of Birmingham, Birmingham, England

Adult Ss made distance bisection judgments over a surface on which the packing density of the texture elements was progressively increased along the Ss' line of sight from one end of the surface to the other. Distance judgments were significantly different under monocular and binocular conditions of vision; however, with binocular vision, Ss did not detect the deformation in the texture on the surface. This result does not support predictions derived from Gibson, Purdy, and Lawrence (1955) concerning the role of gradients of binocular disparity in Gibson's psychophysical theory of space perception.

In his theory of visual space perception, Gibson (1950, 1959) maintained that all the information necessary for veridical three-dimensional space perception is contained in the pattern of stimulation on the retina. The texture density gradient of stimulation was proposed as a chief source of information to depth. Gibson, Purdy, and Lawrence (1955) recognized, however, that on its own, a single static monocular texture density gradient is an ambiguous stimulus, since it corresponds to a family of tridimensional arrangements of surface slant and spacing of the texture elements. The ambiguity is removed only when other gradients of stimulation, in particular, gradients of binocular disparity, are also present. Although more recent statements of Gibson's theory (1968) embody certain changes in emphasis, Gibson still maintains that "motion perspective or binocular perspective eliminates the ambiguity in static perspective and provides information for perceiving the objective slants of surfaces and the abnormal proportions of their edges." On a surface, if the elements of the texture density gradient do not correspond to physically equally spaced objects, then with binocular vision, Ss become aware of this through the conflict between the gradient of disparity and the gradient of texture density. Under such conditions, Gibson et al (1955) predicted that "when a gradient of disparity wins out over a conflicting gradient of texture density, it does so at the cost of giving the phenomenal texture an uneven scatter or uneven spacing, that is deforming it." Using an "optical tunnel," Gibson et al confirmed this hypothesis by showing that Ss with binocular, but not monocular, vision became consciously aware of the physical inequalities in the spacing of texture elements along the walls of the optical tunnel. Gibson et al did not investigate how such phenomenal changes in perceived texture might have influenced judgments of relative distance within the optical tunnel. Using different apparatus, the present experiment investigates the effect of conflicting information to depth from two discrepant gradients on judgments of relative distance.

Newman (1971) has shown that with monocular vision, Ss' judgments of the midpoint of a surface are consistently and significantly influenced by variations in the physical packing density of the texture elements on the surface over which the bisection judgments were made. Ss bisected the surface by equating the number of texture elements beyond the midpoint with the number of similar elements in front of it. The following experiment tests whether this influence of texture on bisection judgments, made over a surface with a physically deformed texture, is overcome by the influence of a conflicting gradient of binocular disparity when Ss are permitted binocular rather than monocular vision. From Gibson et al (1955) it is predicted that Ss should become aware of the deformed texture. They should then attempt to allow for this when judging the midpoint of the surface. However, if the conflict between the binocular disparity gradient and the texture density gradient is insufficient to reveal to Ss the deformation in the texture, then bisection judgments should be influenced by texture alone, remaining unaltered under conditions of monocular or binocular vision. A phenomenally undeformed texture density gradient would remain a subjectively valid indicator of distance so that, from the principle of psychophysical correspondence, it alone should determine distance judgments and not serve as merely a probable indicator of distance.

METHOD

Apparatus

Figure 1 shows a schematic diagram of the apparatus, which has been fully described by Newman (1971). It featured a viewing box into which S

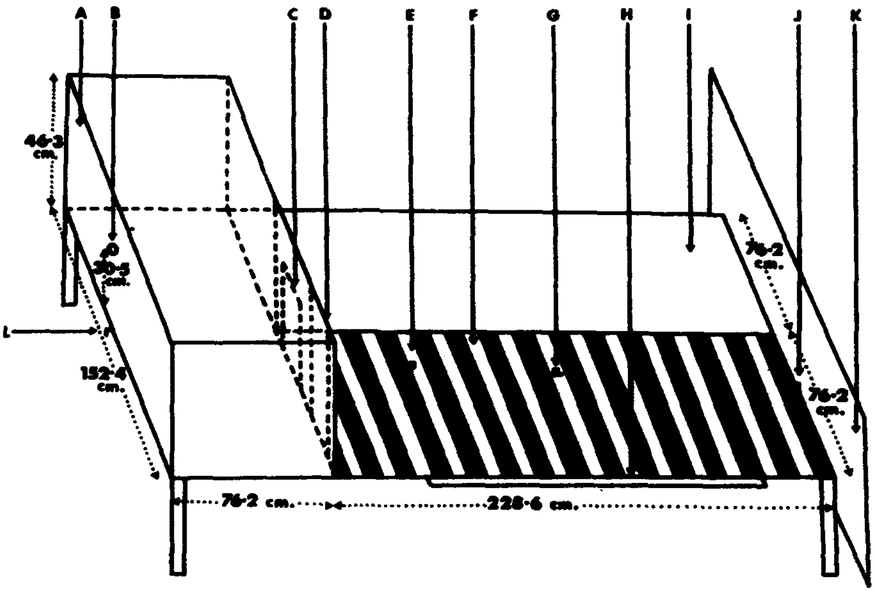

Fig. 1. Schematic diagram of the apparatus. (A) Viewing box; (B) monocular or binocular viewing aperture; (C) reduction screen with aperture; (D) sliding door; (E) near marker; (F) test surface (compression of stripes towards the horizon is not illustrated); (G) distance bisection marker; (H) measuring scale; (I) alternative test surface, occluded throughout this experiment; (J) far marker; (K) background occluding screen; (L) winding handle.

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looked through either a monocular viewing hole, 1.91 cm in diam, or a binocular viewing slot, 10.16 cm wide x 1.91 cm high, located at the front end of the box 30.5 cm above its floor. Adjustable buffers touching S's temples prevented lateral movements of S's head. When the door in a reduction screen facing S was opened, he looked along a horizontal test surface, 228.6 cm long. The surface had a physically deformed texture. It was painted crosswise to S's line of sight with 63 alternating black and white stripes. The stripe nearest to S's viewing position was 5.08 cm wide, each successive stripe was 1/90th narrower than the previous one, making the final horizon stripe 2.50 cm wide. Vision beyond the end of the surface was restricted by a white screen, mounted vertically. Two wooden rods, 1.27 cm tall x 1.27 cm in diam, served as markers defining the distance to be bisected. The "far marker" was placed almost at the horizon end of the test surface, the "near marker" 30.5 cm from the end of the surface abutting the floor of the viewing box. A distance bisection marker, consisting of a wooden rod, 0.97 cm tall x 1.27 cm in diam, mounted on a magnetic disk, 2.79 cm in diam, was placed on the surface above a powerful button magnet, mounted on tracks, and held immediately under the test surface. By winding a handle, S could vary the position of the bisection marker along the direct line of sight between near and far markers. The position of the bisection marker could be read from a scale mounted beside the test surface and visible only to E.

Procedure

There were 32 adult Ss of both sexes, with normal or corrected normal vision. Half of the Ss made distance bisection judgments monocularly, the remainder made the same judgments binocularly. Ss were tested individually. They were instructed to move the distance bisection marker to the physical midpoint between the far and near markers. The psychophysical method of adjustment was used, each S's point of subjective equality was calculated as the average locus of the judged midpoint on four trials. Precautions were taken to ensure that Ss did not deliberately count the stripes when making bisection judgments (see Newman, 1971). At the end of the experiment, Ss were questioned and asked to describe the physical distribution of stripes on the surface.

RESULTS

Questioning at the end of the experiment revealed that no S under either viewing condition was able to describe correctly the physical changes in the widths of successive stripes on the surface. Descriptions of the surface were no different from those of Ss in Newman (1971) when all Ss had been restricted to monocular vision. At the end of the experiment, many Ss from both conditions expressed considerable surprise when shown the deformed texture on the surface.

Each S's mean judgments were expressed as deviations from the objective midpoint; positive deviations were recorded when the bisection marker was placed objectively beyond the midpoint, negative deviations, in the reverse situation.

Mean deviations from the midpoint were as follows: Monocular vision: 17.2 cm ±17.2 cm and binocular vision: 11.8 cm ±10.2 cm. These means were not significantly different, $t(30) = 1.06$, $p > .05$. Inspection of the raw data indicated that judgments of two Ss under the monocular condition were discrepant with those made by all other Ss in the experiment. Questions at the end of the experiment revealed that both Ss had misinterpreted the instruction to place the bisection marker at the physical midpoint. They had attempted to bisect the distance between far and near markers as if the surface were in the frontoparallel plane. As a result, they placed the bisection marker about 24 cm in front of the objective midpoint. With scores for these two Ss removed from the analysis, the difference between the binocular mean and monocular mean (now 21.9 cm ±11.2 cm) was significant, $t(28) = 2.44$, $p < .05$. However, since rejection of Ss is normally inadmissible, the binocular mean was compared with the mean for monocular judgments made by 16 different Ss tested under identical conditions (mean: 24.1 cm ±10.2 cm). The difference in these means was significant, $t(30) = 3.23$, $p < .01$. The mean for the 16 Ss under the binocular condition was significantly different from the mean for the combined group of all 32 Ss under the monocular condition (mean: 20.6 cm ± 14.7 cm), $t(46) = 2.12$, $p < .05$.

DISCUSSION

The predictions derived from Gibson et al (1955) were not confirmed. Although binocular judgments of the midpoint deviated significantly less from the objective midpoint than did monocular judgments, deformations in the texture on the surface over which judgments were made were not perceived with binocular vision. A gradient of binocular disparity thus influenced relative distance judgments, despite the presence of a conflicting gradient of texture density, but without phenomenally deforming it.

This result shows that under these experimental conditions the addition of a gradient of binocular disparity was insuffïcent to remove the inherent ambiguity in a single static monocular texture density gradient. This ambiguity of information to depth in the texture density gradient may be removed only when additional gradients, like motion parallax, are also present and in conflict with the texture density gradient.

Results show that even with binocular vision, the texture density gradient remained a subjectively valid indicator of distance, being phenomenally undeformed. Despite this, Ss' judgments were influenced by the conflicting gradient of binocular disparity. This presents a challenge to Gibson, since it implies that in their judgments, Ss with binocular vision were affording less phenomenal importance to the distance information in the gradient of texture density than did Ss with monocular vision. The texture density gradient was thus responded to as only a probable indicator of distance. Perception cannot be "directly given," as Gibson argues, if subjectively valid gradients of stimulation indicate only the probable nature of the environment. To support Gibson, gradients of stimulation should influence distance judgments in an all-or-nothing manner, otherwise they serve as merely *cues* to distance, a view which Gibson rejects.

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