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SOME SIMPLE OBSERVATIONS ON THE COMBINATION OF VISUAL INFORMATION FROM BINOCULAR AND MOTION PARALLAX

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Under normal conditions both binocular and motion parallax give information about the distance of objects in the field of view, and this information is concordant: that is to say, if binocular parallax tells one that two objects are at certain distances, then a sideways displacement of the head will provide motion parallax cues that agree with those from binocular parallax. When viewing stereograms this is not the case: since the images for both left and right eye lie in the same plane there is no motion parallax from a small lateral head movement no matter what binocular parallax exists and hence no matter what the apparent distance of the object. There are however other changes in the images that we shall discuss shortly. As many people have observed, the perception that results under these conditions is that relative movement occurs in the objects seen. This apparent movement disappears completely if one eye is shut, so discordance between binocular and motion parallax is necessary for the apparent motion to occur.

Upon analysis one finds that the apparent relative movements are such as would be required, in the real world, to nullify the motion parallax expected from a head movement. Thus if one moves one's head to the right, an object in the background will appear to move to the left to maintain an unchanged alignment with an object in the foreground. As Rock points out, this is a nice example of the "intelligence" of the perceptual system: it postulates the movements required to reconcile the absence of motion parallax with the observed binocular parallax, and these postulated movements are what one experiences.

The first question to ask is "How is the perceptual system informed that movement has occurred and therefore motion parallax is to be expected?" Without this information one would presumably experience an undisturbed view of the world with depth provided only by binocular parallax, but the view is disturbed by the apparent motions that have been described, and hence information of the movement must have been received. Some simple additional observations provide partial answers to this question.

1) Instead of moving the head actively from side to side, get someone else to move the stereogram from side to side so that movement is experienced passively. The efferent signals that initiate and control the movement do not now occur and cannot act as sources of the expectation of motion parallax. With passive movements the apparent motion is considerably reduced, but it is not eliminated completely.

2) The lateral acceleration and deceleration associated with the movement could take the place of the efferent signals above, but they too are eliminated when the movement of the stereogram is experienced passively. The conclusion is that the efferent signals for movement and messages from vestibular organs may give rise to some of the expectation of motion parallax, but there is also another source.

3) The foregoing observations suggest that there are changes in the image itself, resulting from a lateral movement, that give rise to expectation of motion parallax. This could be the actual motion of the whole image over the retina, but the following observation rules this out. A small rotation of the plane surface containing a stereogram exactly reproduces the geometric effects of a small lateral shift of viewpoint, but will be unaccompanied by shift of the images. Such a rotation gives rise to the apparent relative motions as effectively as passive lateral shifts.

4) A small rotation of an image causes one side of the image to come closer, one side to recede. This a) enlarges one side and diminishes the other, and b) increases crossed dis-

parity on one side and diminishes it on the other. Closing one eye eliminates b) and also eliminates the apparent relative motions. Therefore the geometrical (trapezoid) distortions by themselves do not cause the expectation of motion parallax.

5) The apparent motion occurs in the visual scene when the head or the stereogram are moved vertically instead of horizontally, or when tilted about a horizontal instead of a vertical axis.

The conclusion at the moment is that when viewing a stereogram and moving the head motion parallax is expected a) from efferent signals of head movement and/or vestibular signals of linear acceleration, and b) from differential changes in disparity of objects in the scene at opposite sides of the scene viewed.

These observations suggest that apparent distances are included in the internal representation of a visual scene, and the changes in some of these distance values cause others to be checked for consistency: if other values are inconsistent with the first changes being caused by a simple shift of viewpoint, then estimated lateral and vertical coordinates are adjusted, causing apparent movement.