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  After Images and Computing Gaze Direction

2.1 Sasha Petrov. "Gaze direction, cyclo-torsion and after-images".

2.2 The basic experiment was to look at afterimages, either evoked by (i) a spot or (ii) a flash of a whole room scene, and see how they seemed to move or jump around in the dark as the head and eyes were voluntarily moved about. The experiments thus revealed the contribution of extra-retinal information in deciding the direction in visual space of retinal activity. If extra-retinal activity was significant then the after-images would be interpreted as originating in different parts of space as the eye moved around. For example, if you were to look straight ahead and see an object along the line of sight, and then you looked up and to the right and saw the same object STILL along the line of sight, then you would interpret this as indicating that the object had moved to the new location (up and to the right), provided you knew your eyes had moved in space.

2.3 Here is Sasha's list of what happens to these two types of after-images (a dot or a whole room) during nine manipulations. They can be found listed in Zenkin and Petrov (1976) Physiology of Man 2 (6):

2.3.1 Saccade between two fixation points in a plane:

After image of spot seems to jump in space to the location of the new fixation point. After image of room seems to stay stable and the fixation points seem to jump.

2.3.2 Saccade between two fixation points differing in depth

After image of spot seems to jump in space to the location of the new fixation point and to change in size, shrinking when the eyes converge. After image of room seems to to stay stable and the fixation points seem to jump in depth exchanging positions with one another (and changing their sizes).

2.3.3 Smooth pursuit of a fixation spot in a plane

After image of spot follows the fixation spot, the fixation point is seen as moving. The after image of the room and the fixation point both appear not to move but to remain earth-stationary.

2.3.4 Smooth pursuit in depth

As for 2.3.3 but with the same changing size illusions as 2.3.2.

2.3.5 Yaw head rotation

After images of spots or rooms appear to follow head rotation.

2.3.6 Roll head tilt

After images of spots or rooms appear to follow head tilt.

2.3.7 Linear motion

After images of spots or rooms appear to shrink (when you move towards them) or contract (when you move away from them).

2.3.8 Yaw head rotation with self-stationary vision

After images of spots or rooms appear to rotate with the head in the same direction. The fixation point also seems to follow the head.

2.3.9 Linear motion with self-stationary vision

After images of spots or rooms appear to follow the head and not change size.

2.4.1 For eye movement (2.3.1-2.3.4) the principle that underlies these observations is that extra-retinal eye position information can explain the behaviour of a dot after image, but that the behaviour of a room after image suggests that, under those circumstances, extra-retinal information contributes relatively little (cf. Pelz and Hayhoe, 1995, Vis Res 35: 2267).

2.4.2 A strange observation was that during condition 2.3.1, with an after-image of a room, the eyes tend to return to the eye-in-head position where they were when the after-image was created. A possible reason for this that was discussed is the dominance of visual information over extraretinal information in eye position control. The original eye position is the only one compatible with the various disparities in the two eyes' images. The horizontal disparities define the left/right position of the eyes and the cyclo-disparities define the up/down eye position as follows: Donders' Law states that for a given eye-in-head position, there will be a certain torsional pose of the eye. In particular, for up/down elevations there is a systematic torsional effect. This means that if the eyes adopt a new vertical position in the orbit under normal circumstances this would result in predictable twists of the images of the two eyes: predictable cyclodisparities. Maybe the visual system can use this cyclodisparity for the recovery of visual elevation angle of the images.

2.4.3 For head movement (2.3.5-2.3.9) there is no difference between the behaviour of dot and the room after images, confirming the significance of extra-retinal information in processing head movement.

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