- Friday, January 5, 1996
  Head Movements and Depth Perception

1.1 The meeting was presented by Hiro Ono. He was talking about head movements and depth perception: `parallactic depth'.

2.1 Wallach in 1985 showed that during a head movement, a small amount of actual motion is not noticed. The amount of motion that can occur and not be detected was called the `zone of immobilization'. It seemed that the motion was interpreted as resulting from the head movement and not allocated to REAL motion.

Hiro's comment: I THINK WALLACH WILL AGREE WITH WITH THIS, BUT I DON'T. IN MOST OF HIS STIMULUS ARRANGEMENT, THE EYES ROTATED COUNTER TO THE HEAD ROTATION, AND THERE WERE NO "RETINAL MOTION" TO ALLOCATE.

2.2 When you move your head from side to side in front of an three dimensional object, objects or surface, then you get parallax in which parts at different distances move with different retinal velocities. If this differential movement is SIMULATED on a screen of random dots then an illusory 3D surface is seen. For `small' movements ONLY depth is seen: for `bigger' movements, depth AND movement are seen.

2.3 The system for allocating retinal movement as resulting from a head movement seems to have some limits. For larger movements, some retinal motion is `unallocated'.

3 Experiments were described in which subjects moved their heads from side to side about +/- 10cms with periods of constant velocity. A chin guide was used to assist this. Subjects viewed a screen of random dots that was divided into horizontal bars. Alternate bars moved in opposite directions linked to the head movement.

3.1 Exp 1. Subjects adjusted the speed of the dots to `mark out' borders between three perceptions: a) DEPTH and MOTION, b) DEPTH ONLY and c) neither DEPTH nor MOTION. Results could be plotted as RETINAL MOTION (mins arc/sec) or equivalent disparities (Equivalent disparity corresponds to the disparity that WOULD result if parts of the screen were REALLY at the depths commensurate with their image' retinal behaviour) as a function of head velocity.

For head velocities below 0.5 cm/s, depth alone was never seen. Above about 0.5 cm/s there was a range of retinal velocities (or equivalent disparities) where `pure depth' could be seen (without motion): higher retinal velocities and MOTION was seen as well as depth: lower retinal velocities and neither depth nor motion was seen. For head velocities between about 0.5 cm/s and 10 cm/s, the threshold (in equivalent disparities) for depth perception (between `depth' and `nothing') was inversely proportional to the head velocity: for velocities above 10 cm/s it was about constant. Could this correspond to a ZONE of depths and head movements where PARALLAX worked perfectly?

3.2 Exp 2. Keep equivalent disparity constant (within the range of the zone delineated in Exp 1), vary head velocity and measure perceived depth. When this was done, parallax turned out to work effectively (provide correct depth information) if the head velocity was above 10 cm/s.

3.3 Exp 3. Choose a head velocity above 10 cm/s and vary equivalent disparity (measuring perceived depth). This supports the other two experiments by showing perceived depth proportional to the equivalent disparities up to a certain limit (the edge of the `zone') whereupon the perception of depth was gradually replaced by the perception of motion.

3.4 Exp 4. Equal depth contours. Subjects were given a STANDARD depth (between 1.6 and 0.2 cm presented on the same screen during a similar head movement) and asked to MATCH the perceived depth for various head velocities. The results were veridical above 10 cm/s but below that you needed MORE retinal velocity to generate the same perceived depth. Or put another way, for slow head movements, depth from parallax is underestimated.

4 Discussion focussed on what exactly was meant by `perceiving motion' in this context: during real, natural, lateral head movements, relative motion IS observable between objects but at the same time, it is not interpreted as movements of objects in the world. So there was some doubt about what the subjects were actually doing.

It was pointed out that the `discontinuous' nature of the stimulus (bars with sharp edges) as opposed to a gradation of movement velocities, made comparison with some related work difficult.

Although no effort was made to identify the source or sources of information that the subjects might be using concerning their head movement, obviously vestibular stimulation of the otolith is likely to be relevant. It was pointed out that, although the otoliths transduce ACCELERATION, the time it takes to detect a constant acceleration varies with the acceleration such that the time to detection x acceleration is a constant called the Mulder constant. No one could remember the value for this constant, but I have now looked it up and it is about 20 cm/s. Whether this is relevant in view of the unspecified pattern of accelerations PRECEDING the period of constant velocity, is a matter for further investigation.

For low speeds of head movement, however, it would seem likely that the otoliths would be underestimating the head movement. But if head movement is underestimated, a given retinal velocity should be seen as a GREATER depth, since it is thought to result from a smaller head movement: the data suggest the opposite.

5.0 see you next time!

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