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Head-bobbing in pigeons: Evidence for differential motion parallax computation during landing flight

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Pigeons as well as many other birds show a characteristic head-bobbing motion during walking, pecking and other behaviours: Hold-phases during which the retraction of the head compensates the forward motion of the body alternate with thrust-phases during which the head is saccadically extended forward. Based on the observed stabilization of the head during the hold-phase of the walking pigeon head-bobbing is interpreted to be an optokinetic response.

Head-bobbing also occurs during flight. In that case, however, the bird travels with a speed that can not be compensated by the retraction of the head. Our hypothesis is that head-bobbing is not only an optokinetic reaction that serves image stabilization but that it is used to derive depth information from differential motion parallax. A flying bird has the problem that it does not have direct access to information about its own velocity over ground -- a prerequisite needed to compute depth from standard motion parallax. Proprioceptive systems can provide information about velocity relative to the surrounding air, but motion of the medium itself (wind, convection) can add a further velocity component. Differential motion parallax computation might be the solution to that problem: The eye is moved with two different velocities. Comparing the difference between these velocities with the difference between the corresponding retinal image velocities can reveal distance.

We tested this hypothesis by measuring the pigeons head-motion during the approach to a perch. In this situation precise distance information is particularly important to the bird. However, to induce optic flow of the landing site on the retina the motion of the eye has to have a component perpendicular to the line along which the pigeon travels. The data show that head-bobbing does indeed contain such a component. The birds move their head not on a straight line from one hold position to the next but on a curved, U-shaped trajectory that would induce substantial optical flow of the landing site on the retina.

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