AN ETHOGRAM OF THE PIGEON'S BOWING DISPLAY

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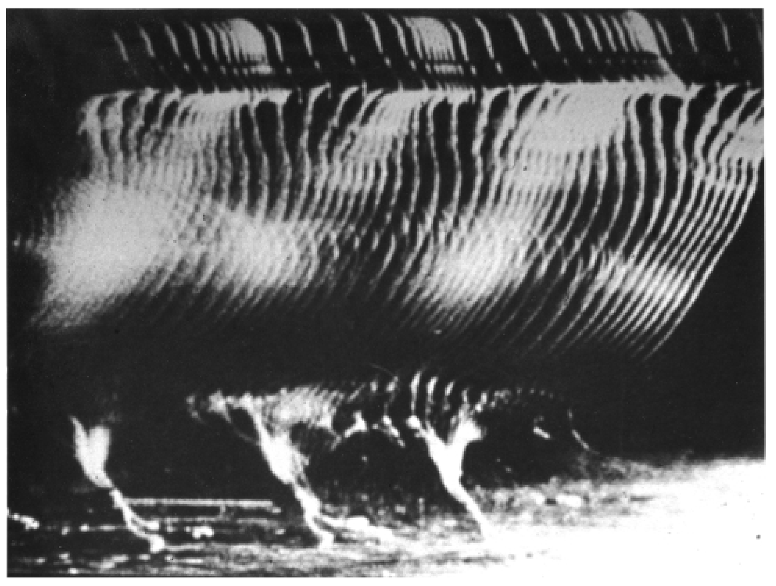
INTRODUCTION



ig. 1: This stroboscopic image from a walking igeon illustrates the typical head bobbing hich consists of a period where the head emains fixed in space (hold phase) and a eriod where it is moved quickly forward thrust phase). From: Frost 1978.

ourtship behaviour in pigeons can be used to tudy the perceptual and neurophysiological asis of conspecific recognition. The present tudy characterizes the particular motion patterns uring courtship and compares them with regular alking patterns.

main characteristic in both regular walking and ourting is the head bobbing consisting of a hold nd a thrust phase (Fig. 1). Whereas the hold hase is considered to be used for image tabilization it is not clear if the saccadic thrust hase has any function but bringing the eye to a ew position. The present detailed analysis llows us to draw conclusions about a possible nction of the thrust phase.

ig. 2: Pigeon bowing in the runway.

2 METHODS

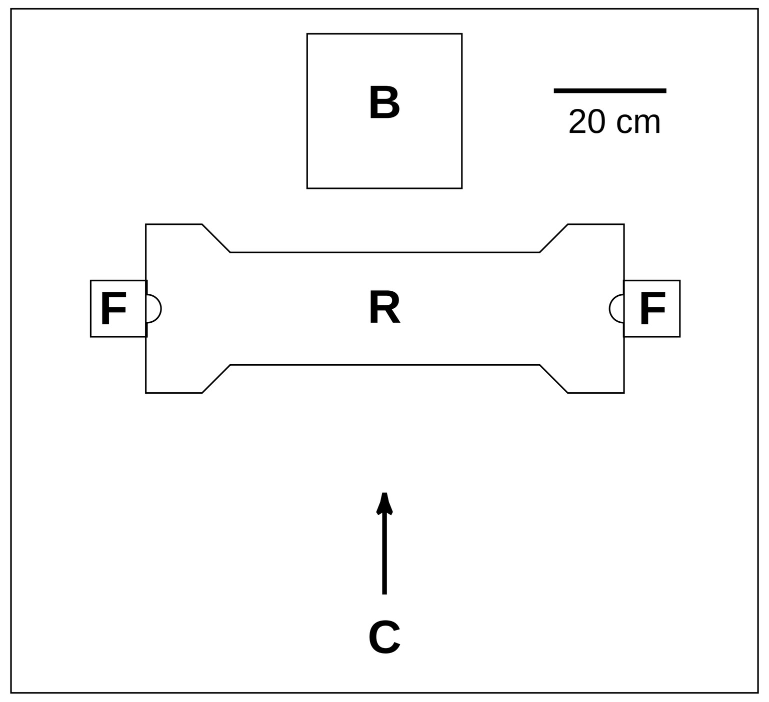


Fig. 3: Schematic drawing of the experimental setup as seen from above. R: Runway, F: Food hoppers, B: Plexiglas box holding the female bird, C: viewing direction of the camera. The camera was 3.5 m away from the runway.

A male pigeon was placed into a plexiglas runway as illustrated in Fig. 3. There, it was confronted with one of two situations:

1. Two food hoppers were mounted on the walls at the ends of the runway. A light barrier detected when the pigeon inserted its head in one of the hoppers and triggered food delivery at the other hopper. The bird learned quickly to walk back and forth between the feeders.

2. A plexiglas box with a receptive female pigeon was placed next to the runway. The test bird immediately started to perform courtship display, parading along the runway.

Both regular walking between two feeders and courtship display was video taped from a distance of 3.5 m.

35 regular walks and 35 courtship walks were digitized (temporal resolution 60 frames per second) and three features were tracked in the images: The eye and both the central part of left and the right foot.

Digital filtering of the horizontal component of the eye movement yielded markers for the onset of the hold phase and the onset of the thrust phase.

Digital filtering of the vertical component of the movement of the feet yielded markers for the first frame, in which a foot was lifted from the floor.

Using these measures we derived the following parameters for each run:

- **Overall velocity during the run**
- **Average duration of the hold phase**
- **Average duration of the thrust phase**
- **Velocity of the head during the thrust phase**
- **Phase shift between head bobbing and feet lifting**

3 RESULTS

1. Comparison of movement patterns during regular walking and courtship display

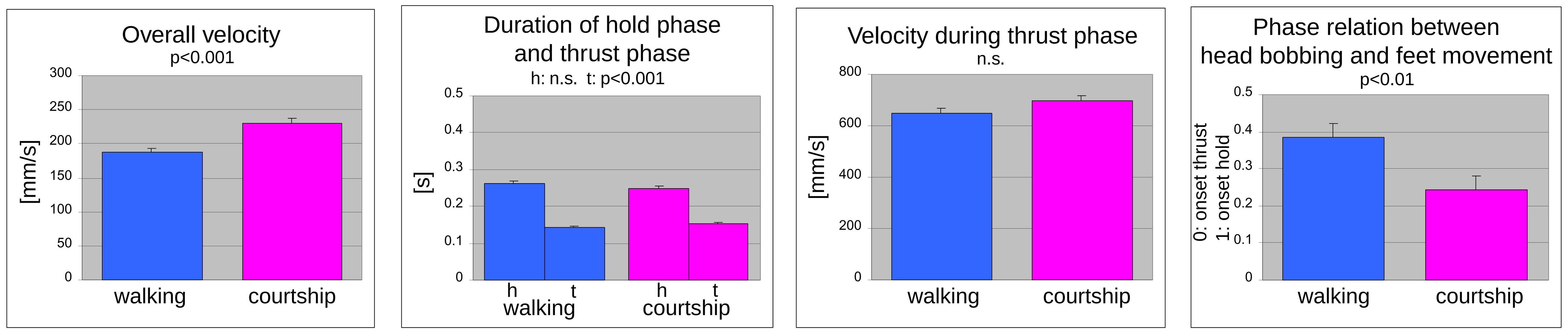


Fig. 4: Results of the motion analysis. The bars represent a means over 35 runs. Errorbars show standard errors. Statistics is based on t-tests.

- Courtship runs are faster.
- The time for a whole cycle (hold-thrust) is remarkably constant.
- The increase in speed is due to an increase in thrust amplitude and only to a much smaller extent to an increase in speed during the thrust phase.
- The time when feet are lifted from the floor is precicely coupled to the head bobbing and occurs always in the first half of the thrust phase. Still there are significant differences between normal walking and courtship runs.

2. General observations regarding the role of hold and thrust phase

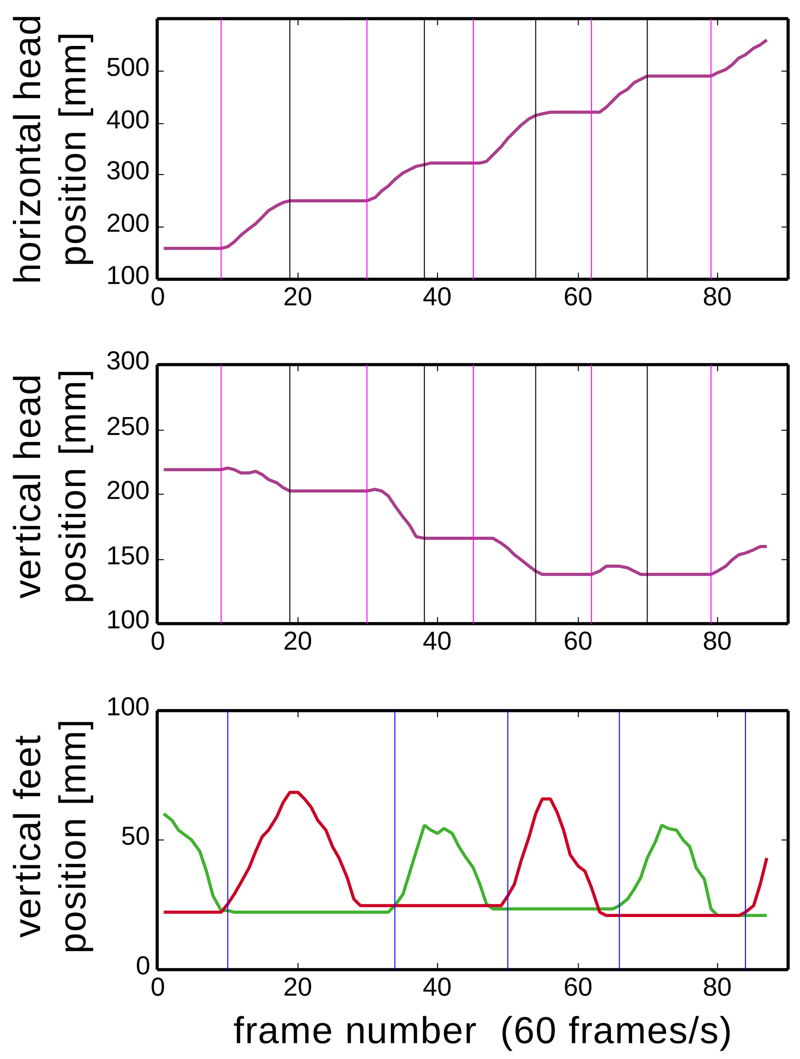
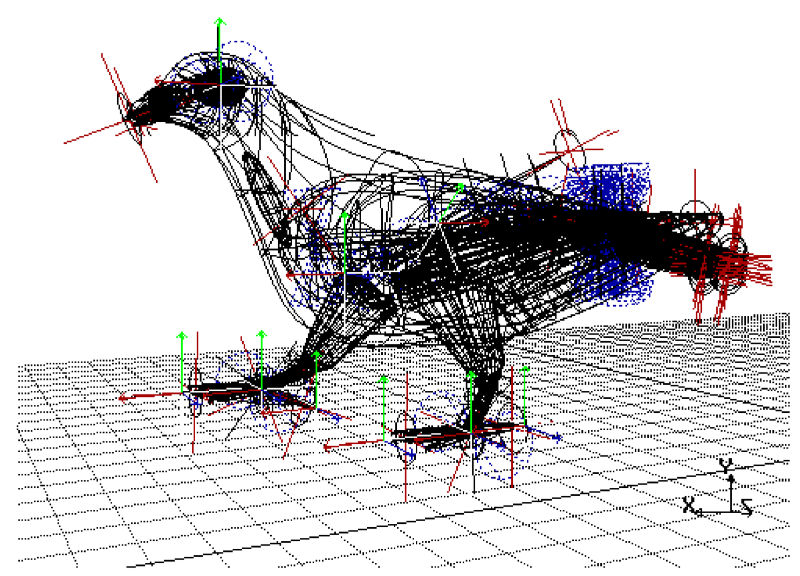


Fig. 5: Example for the motion trajectories from a single courtship run. The vertical lines in the two upper panels show the onset of the hold phase and the onset of the thrust phase as derived from the horizontal movement data of the head. The vertical lines in the lower panel mark the time when a foot starts lifting.

- During the hold phase, not only the horizontal movement is frozen but there is also no vertical or other kinds of translational or rotational motion.
- The horizontal movement of the head during the thrust phase is remarkably stereotyped: With only very short periods of acceleration and deceleration the velocity during the thrust is held constant.
- This is not in accordance with just bringing the head optimally from point A to point B, but rather suggests visual processing during the thrust phase.
- The vertical movement during the thrust phase appears to be much less constrained.



4 DISCUSSION

Motion patterns

We analysed the pigeon's movements during regular walking and courtship display and characterized a set of parameters that are candidates for carrying information in the context of social recognition. Not all these parameters are necessarily diagnostic for a bird's **action** (courtship vs. walking) but may also carry information about a bird's **identity**. Collecting data from more birds will reveal the diagnosticity of the different behavioural parameters.

The data will be critical to animate our "virtual pigeon", a computer generated model that will be used to replace live birds and video stimuli in future studies (Fig. 6, see also Poster by Frost et al.).

Vision during hold and thrust phase

During the hold phase, the head is kept fixed in space and neither translational nor rotational movement in any direction occurs.

The fine structure of the kinematics of the head during the thrust phase shows that the horizontal component of the movement is highly constrained and accurately tuned to achieve constant horizontal velocity. The vertical component, on the other hand, does not show this behaviour.

The very accurate fine structure and, in particular, the constant horizontal velocity of the head during the thrust phase suggests, that visual information processing occurs not only during the hold phase but also during the saccadic parts of the head bobbing. We suggest that rather than solving all kinds of visual tasks in parallel, head bobbing birds subdivide the information processing over the two interlaced phases. Whereas the image stabilizing hold phase presumably supports pattern recognition and the processing of object motion the thrust phase might be used to obtain 3D spatial information from motion parallax.

Fig. 6: Towards the "virtual pigeon": Using an animated computer model, we will feed the obtained motion patterns back into neuroethological experiments.