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Neuroethology

Neural Response to Naturalistic Optic Flow in the Zebra Finch

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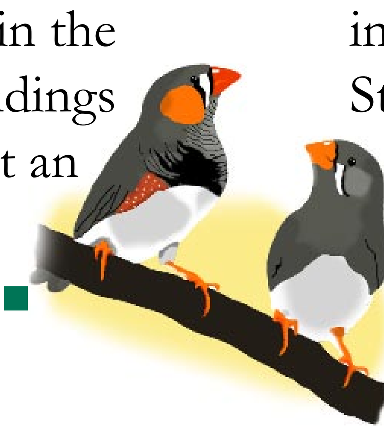
Introduction:

Birds like the zebra finch use the optic flow to determine the distance to an object for navigation in flight[1]. Therefore, motion processing is a central task for the avian visual system.

Recent studies in pigeon show that background or whole field information from other brain areas affect processing of object motion in the tectofugal system[2-3]. Here we want to introduce a characterization of motion sensitive neurons in the nucleus rotundus of the zebra finch. We present the most important findings from responses to 'conventional' whole field stimuli. In addition we present an approach to studying naturalstic motion stimuli in birds.



Conclusions:

Finding two distinct response latency groups is in accordance with an earlier study on nucleus rotundus of the zebra finch[4] where differences were found in regard of contra- or ipsilateral input.

Tonic response to whole field motion in the tectofugal system was never reported before. The reason may be that we used a complex whole field stimulus consisting of many single objects distributed in three dimensional space.

Strong habituation effects may occur from the system adapting to self motion to allow better coding of single objects as was found in flies[5]. This finding helps designing further experiments on natural processing.

Results:

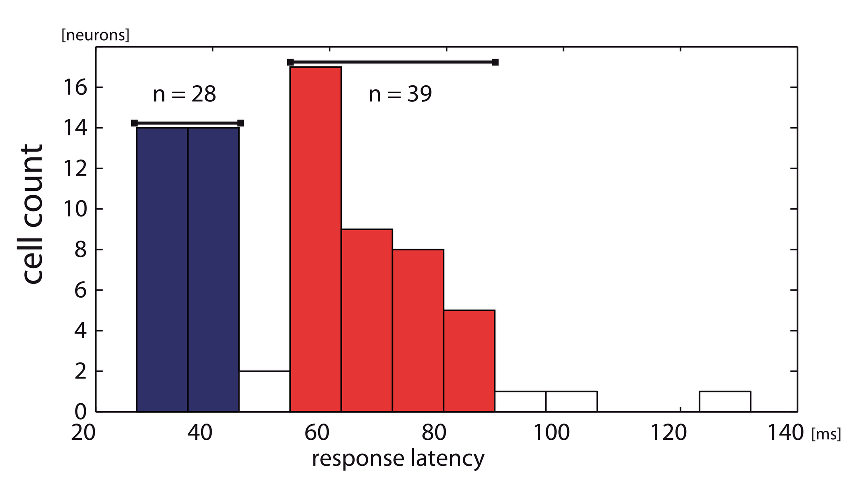
1 Neurons responded to whole field motion.

The neurons did not respond to a standing image. Activity rose with motion onset and was responded to tonically or with a short transient response (see figure 4).

2 Whole field stimuli cause a strong habituation effect.

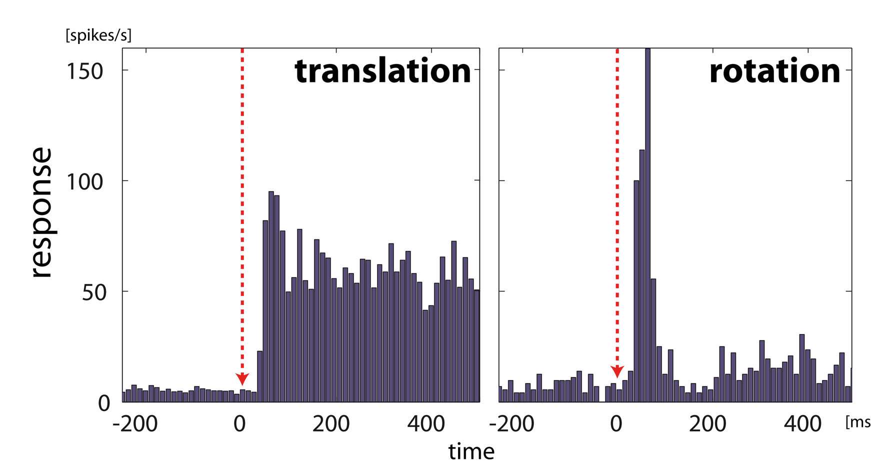
In a pair of consecutive self motion stimuli the response to the second was usually smaller. This effect is stronger than direction preference effects (not shown).

3 Two response latency groups.



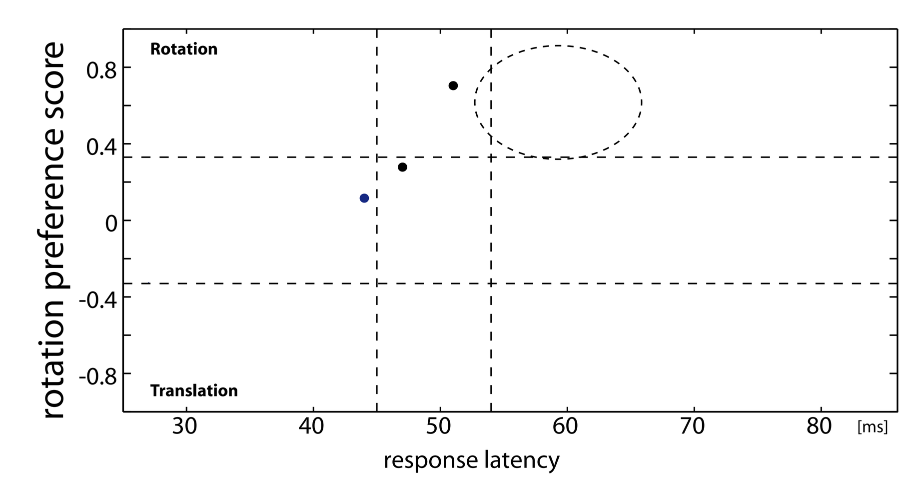
Response latency to stimulus motion onset was measured (n=72). The histogramm shows two groups of neurons with short or long response latencies.

4 Preferences for translation or rotation.



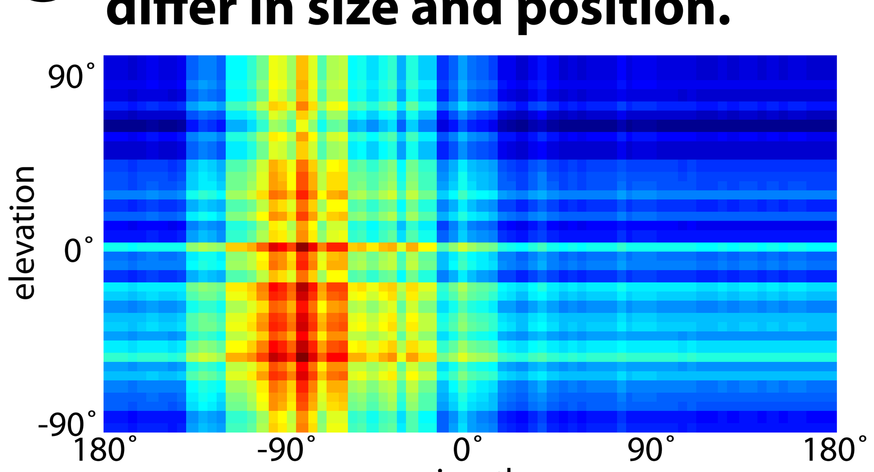
The bar plot shows the mean response to translational and rotational self motion from a single neuron. The sharp transient response to rotational self motion is typical.

5 Self rotation preferring neurons have longer response latencies.



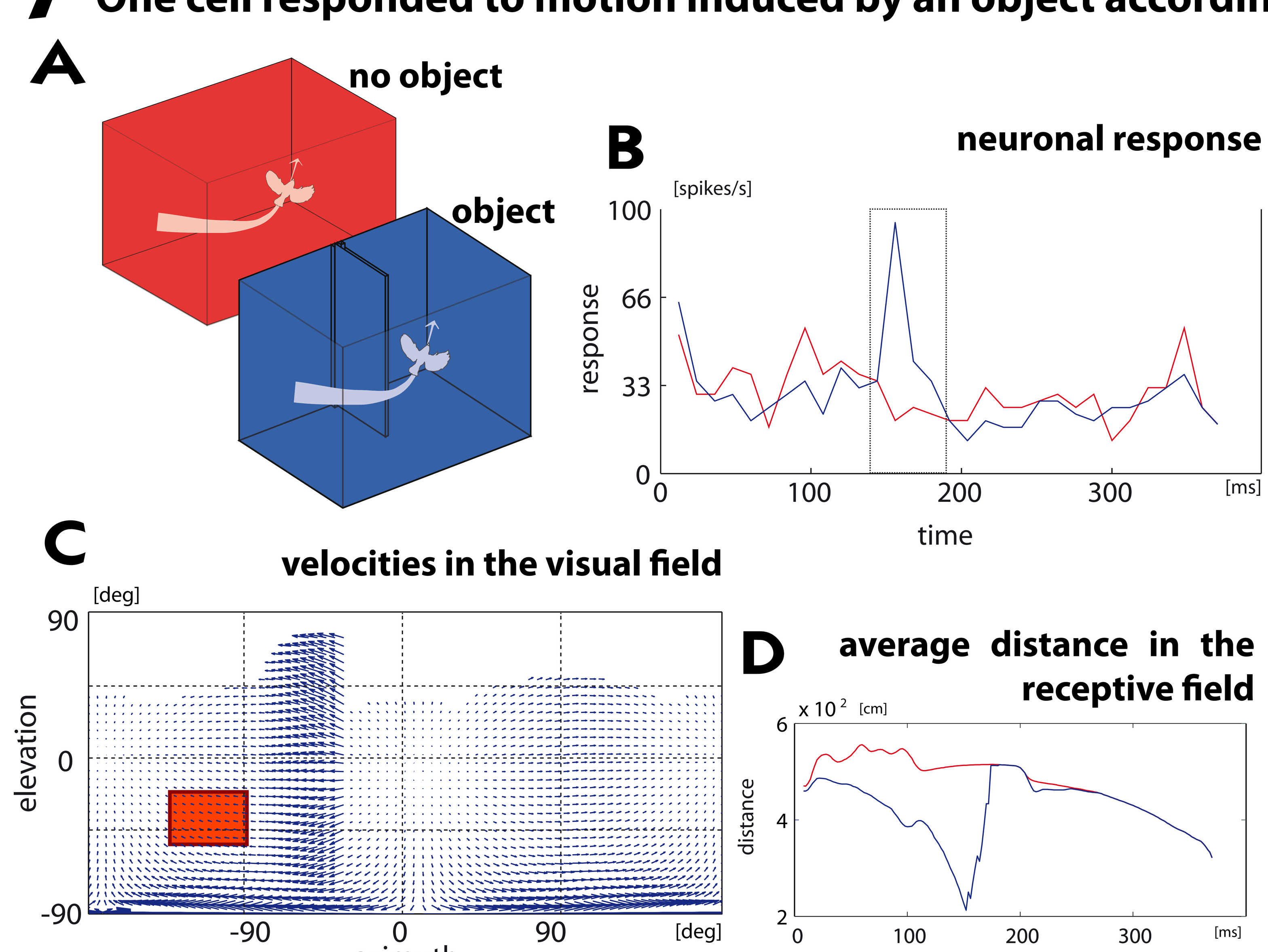
We calculated a score to quantify the preference for the mode of self motion. The score is plotted against response latency. Colors correspond with response latency groups (see figure 3).

6 The receptive fields of neurons differ in size and position.



We found three main types of receptive fields. Two of them were found exclusively in the area covered by the contralateral eye. The third also shows ipsilateral activation. In this cylinder plot an example of the most common type is shown. The receptive field corresponds to the area in which activity peaks from vertical and horizontal scans meet (red area).

7 One cell responded to motion induced by an object according to optic flow parameters.

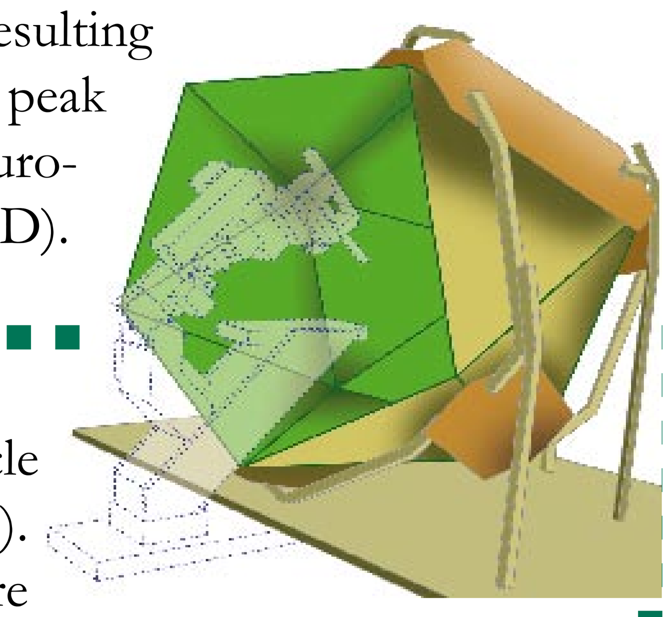


We presented the bird a naturalistic replay of a flight during which the bird passed a wall to the right. The probe was the same stimulus but the wall was removed (7A).

One neuron showed a significant peak in spike rate when the object was present (figure 7B, blue line) but not when it was absent (figure 7B, red line).

Figure 7C shows a single frame of the stimulus and iminent velocity vectors within the visual field. High velocities are caused by the wall in the left visual field. The red rectangle indicates the position and size of the receptive field of the neuron.

We extracted the mean distance to objects in the receptive field for each frame. The resulting progression curve shows a peak in coincidence with the neuronal response peak (figure 7D).



Methods:

Birds were anesthetized and presented visual motion stimuli on a panoramic LED display during multi unit recordings in the right hemisphere of nucleus rotundus.

The conventional stimuli were movies in first person perspective resembling self motion in a virtual environment defined by pseudo-randomly distributed globes.

The naturalistic stimulus was a reconstructed obstacle avoidance flight recorded for Eckmeier et. al (2008). The acquired trajectory and head orientation data were used as path for a virtual camera within a virtual model of the original cage. The resulting movie resembled the visual motion input the original bird had experienced.

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