Summary

This thesis investigates the capacities of generalization and categorization of visual stimuli in honeybees (*Apis mellifera*). To this purpose, different behavioural discrimination experiments were performed in which free-flying honeybees were trained to collect sucrose solution on vertically presented stimuli in a Y-maze. The training procedure was either differential, i.e. a single pair of patterns had to be discriminated, or following the principles of typical categorization experiments, i.e. bees were trained to discriminate between two groups of stimuli that were all different but shared a common parameter which could be used for discrimination and categorization. After completed training, bees were confronted with new instances in transfer tests, in order to test their generalization and categorization performance.

Because transfer to pattern transformations such as mirror-images and left-right transformation is a special case among visual generalization tasks, I investigated transfer to these transformations in bees (Chapter I). The results show, that bees generalized to the mirror image and left- right-transformation if the original pattern was absent. After the training with one pattern pair as well as after training to six pattern pairs, they preferred the left right transformation over the mirror image. Following the principle of parsimony, the bees' performance can be explained by known pattern recognition strategies in bees, i.e. the use of a template like representation and feature extraction: in each test they preferred the pattern which had the highest degree of similarity with the rewarded training stimulus. Interpretation of the results in favour of simple pattern recognition strategies led to the idea that bees might have learned patterns containing several different orientations in terms of a configuration of orientations in which each retinal quadrant is associated with a specific orientation.

This possibility was further investigated in Chapter II. Here I asked whether bees are able to combine several orientations in a specific spatial configuration and to categorize novel stimuli conserving or not this configuration. In these experiments, bees were trained to the sequence of six randomised pattern pairs, in order to promote extraction of the orientations. Bees were then presented with novel test patterns with reduced orientation information and a changed configuration of orientations. Supporting the findings of the experiments in Chapter I, in all cases the bees preferred the configuration corresponding to the rewarded group of stimuli over any other alternative presented during the tests. We could thus show, that bees are able to categorize patterns based on a configural representation of four orientations. Additionally, bees were trained to coloured stimuli in which the receptor specific contrasts for the three receptors in the bees visual system (S, M and L-receptors) was specifically suppressed. This was done in order to detect the visual pathway implicated in this kind of task and the results show, that bees only could solve the task with pattern providing M- and L- contrast.

In Chapter III I asked whether a configural pattern representation is a consequence of training to a set of stimuli sharing a common configuration or if it also occurs after a simpler form of training. Moreover, I wanted to know, whether different levels of experience influence generalization and categorization performance. Therefore I tested bees at different stages of the training procedure. The results show, that bees can acquire a configural pattern representation after training to a single pattern pair and that they show a higher degree of generalization to novel instances with a higher level of experience.

Together, the results show that bees can learn a specific configuration of orientations, thus combine several stimulus elements into a generic, configural representation and that this representation changes with increasing experience towards a higher level of generalization to novel stimuli.