# Conclusion & Outlook

In this thesis we showed the following:

Chapter 1: Bees indeed learn second-order conditioning (SOC) and it depends on the sequence of new and previously learnt odor. Also, the sequence of phase was important for SOC.

Further behavior experiments are not necessary as we convincingly proved that SOC occurs. However, it would be interesting to know if at neural level SOC is similar or different from simple acquisition learning.

Chapter 2: We showed that bees can be trained to contexts in relatively short time and multiple contexts not only improve learning but also quicken learning. Electrophysiology experiment showed that alpha lobe neurons of mushroom bodies also respond to temperature changes. After context learning, neuronal response towards rewarded odors was reduced compared to other odors, while response towards rewarded context was increased compared to unrewarded context.

Our experiments were done in relatively short time (4 hours) and since better learning scores can be achieved by increasing the times between two contexts, it would be worthwhile to see if long-term context learning has similar effects as described here.

Chapter 3: Like shown previously, bee show sleep like behavior and unique antennal movements were seen during night and day. After conditioning, bees showed reduced sleep compared to other bees. Sleep depriving did not affect acquisition learning while extinction learning could be effectively blocked. Sleep might be required for memory consolidation of extinction memory but not acquisition memory.

Since memory consolidation involves several molecular mechanisms, it might be important to combine sleep experiments with molecular biology or pharmacology experiments to pin down sleep related memory functions. Also, extracellular recordings during sleep and wake might show neuronal changes during consolidation of memory or similar processes.

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