## Abstract

Songbirds are a widely used animal model for neural mechanisms underlying vocal imitation learning and demonstrates many parallels to human speech. While we have an increasing understanding of the neural circuity underlying the acquisition and maintenance of song in songbirds, little is understood of the biomechanics of the avian vocal organ, the syrinx, due to its small size and location deep inside the body. Therefore, we currently have an incomplete understanding of how central motor areas connect to and instruct the peripheral musculature that controls sound production, as well as how respiratory and syringeal motor systems generate and modify sound output.

In this thesis I use a novel *in vitro* approach to study motor control of the syrinx. In Chapter 1, we examine the organization of the motor pool that controls the syrinx. By combining syringeal muscle innervation ratios with muscle stress and *in vitro* syrinx preparation, we were able to estimate the motor unit (MU) size distribution and control resolution of a key vocal parameter, fundamental frequency ($f_o$). Our results show that the syrinx has one of the highest motor control resolutions in the vertebrate nervous system. Next, in Chapter 2, we quantified the acoustic output of the syrinx *in vitro* when modulated by intrinsic syringeal muscles and respiratory pressures. We systematically shortened two muscles, *ventral syringeal muscle* (VS) and *medial dorsal syringeal muscle* (MDS) and simultaneously modulating bronchial ($p_b$) and interclavicular air sac ($p_{icas}$) pressures. We show that $f_o$ increases when VS and MDS are shortened individually, as well as co-activation. In Chapter 3, we measured the acoustic output over vocal development in the zebra finch syrinx and found that it does not change. Therefore, changes observed *in vivo* must be linked to changes in motor control. The developed methodology allowed us to test several longstanding hypotheses about motor control of peripheral mechanisms of sound production.