VOCAL LEARNING IN BATS: FROM GENES TO BEHAVIOUR

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Vocal production learning (herein 'vocal learning') - the ability to modify vocal signals based on conspecific auditory feedback - is an essential component of human spoken language (Bolhuis, Okanoya, & Scharff, 2010a; Nowicki & Searcy, 2014). Infants learning to speak must perform this task, which includes auditory perception, memorization of target sounds, vocal motor planning and production, sound matching to determine goodness of fit, and modification of the vocal-motor output as necessary (Petkov & Jarvis, 2012). The complexity of this task suggests that multiple neurobiological and genetic mechanisms are likely to underlie its evolution and biological encoding. Given the necessary limitations of studying vocal learning in humans, animal models represent an opportunity to understand the neurogenetic mechanisms underlying this spoken language-relevant trait.

Vocal learning is a rare trait in the animal kingdom. Few non-human species have convincingly shown this trait. To date, vocal learning has been documented in some cetacean, pinniped, elephant, bat and bird species (Bolhuis, Okanoya, & Scharff, 2010b; Janik & Slater, 1997). Songbirds have dominated the study of vocal learning due to their well-defined learning paradigm, sexual dimorphism of their song, their ease of handling and ability to breed in captivity (Bolhuis et al., 2010b; Condro & White, 2014). Mammalian vocal learning has, by comparison, been understudied. Sea mammal vocal learning has been most well documented from this group (Janik & Slater, 2000; Janik & Slater, 1997), however due to their size and habitat they present hurdles for neurological or genetic interrogations. In order to understand the biological underpinnings and evolution of vocal learning, a broad, cross-species comparison, coupled with careful consideration of the components underlying this trait, is crucial.

We are investigating an understudied mammalian example of vocal learning; bats. Bats are highly social animals that have developed sophisticated vocal systems for navigation and communication (Vernes, 2017). Social communication in bats is often facilitated by low frequency calls (in the hearing range) and in some species these calls show evidence that they may be learned (Knörnschild, 2014). Some bat species can also be maintained in laboratory colonies, making them amenable to neurogenetic manipulations (Esser, 1994; Knörnschild, 2014; Prat, Taub, & Yovel, 2015). Thus, their small size, ability to breed in captivity and

sophisticated vocal communications, make bats an exciting mammalian model for the study of vocal learning. We use bats in controlled behavioural paradigms together with neuro-molecular studies to dissect out the biological mechanisms underlying vocal learning. By integrating these findings into a cross-species framework, we aim to understand how neuro-genetic mechanisms can drive a complex behaviour like vocal learning, and ultimately shed light on the biological encoding and evolution of human speech.