Vocal Production & Perception by Chickadees:

Research from the Songbird Neuroethology Laboratory

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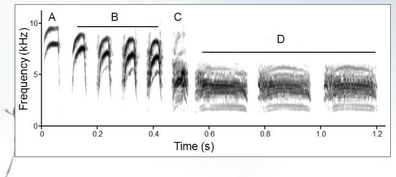
Vocalizations: *chick-a-dee* call

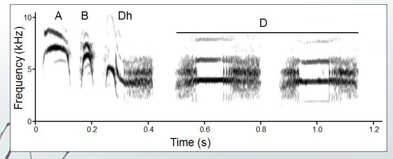
The ***chick-a-dee* call** is one call produced by chickadees

Complex call with multiple note types

Notes follow fixed order: A→ B → C → D



Black-capped chickadee call



Mountain chickadee call

Mountain chickadee (*Poecile gambeli*)

What is a songbird?

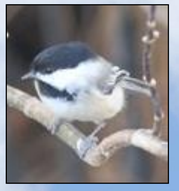
One of six groups of animals that are ***vocal learners***

- Others include: humans, bats, parrots, hummingbirds, & cetaceans

Vocal learners: During development, need to hear adults of the same species in order to produce species-typical vocalizations

Songbirds produce two types of vocalizations: ***calls*** and ***songs***

- For North American songbirds in general:
  - ***Calls:*** simple vocalizations, produced year-round by both sexes
    - Calls are used for flock cohesion, to raise alarm, indicate a food source, etc
  - ***Songs:*** complex vocalizations, produced during breeding season by males only
    - Songs are used to attract mates and defend territories



Black-capped chickadee (*Poecile atricapillus*)

Why study chickadees?

Unlike most songbirds, chickadees have:

- A ***complex*** call & a relatively ***simple*** song
- Chickadees must learn their song and parts of their call
- Males and females both produce song
- In spring, males and females pair up & defend territories
- In fall, birds form flocks with dominance hierarchies

Vocalizations: *fee-bee* song

Black-capped chickadees produce a ***fee-bee* song**, which contains two whistled notes

Fee-bee songs contain information regarding male's dominance status:

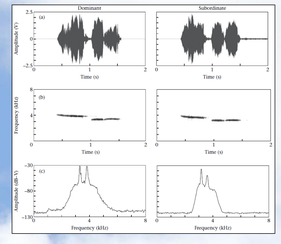


Figure from Hoeschele et al. (2010). *Animal Behaviour*

Both males and females produce songs:

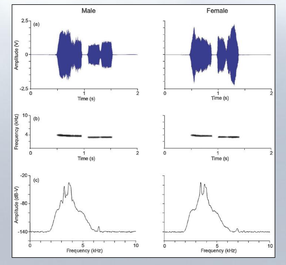


Figure from Hahn et al. (2013). *Behavioural Processes.*

Experimental Methods

Bioacoustic Analyses

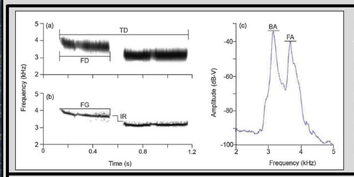
Using sound analysis software, we measure and analyze features of songbird vocalizations.

Using these methods, we have analyzed:

***chick-a-dee* calls** produced by numerous chickadee species

***tseet* calls** produced by black-capped & mountain chickadees

***fee-bee* songs** produced by black-capped chickadees

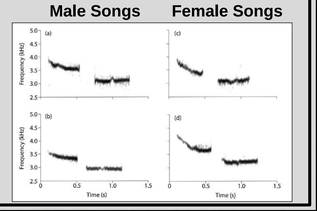


Features measured in *fee-bee* songs include:

TD: total duration of song
FD: *fee* note duration
FG: *fee* glissando (decrease in *fee* note frequency)
IR: interval ratio (frequency ratio between notes)
BA: *bee* note maximum amplitude
FA: *fee* note maximum amplitude

Bioacoustic and discriminant function analyses revealed that *fee* glissando differs between male- and female-produced songs

Male Songs **Female Songs**



Figures from Hahn et al. (2013). *Behavioural Processes.*

Operant Conditioning

Bioacoustic analyses indicate features that are different between vocalizations, but: **Can birds *perceive* these differences?**

To examine ***perception***, we use an operant conditioning paradigm.

We train birds to discriminate vocalizations (or other stimuli such as musical chords).

By manipulating specific features within these vocalizations and presenting these to the songbirds we can understand the ***mechanism*** that birds use to perceive differences in vocalizations.

Schematic of Operant Conditioning Testing Chamber

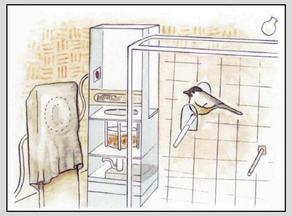
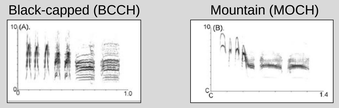


Image from Weisman & Ratcliffe (2004) *American Scientist, 92*

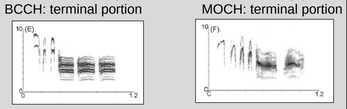
Testing stimuli: *Natural* calls:

Black-capped (BCCH) Mountain (MOCH)



Testing stimuli: *Manipulated* calls:

MOCH: introductory portion BCCH: introductory portion
BCCH: terminal portion MOCH: terminal portion



Figures from Bloomfield et al. (2008b). *Behavioural Processes.*

Neurobiology

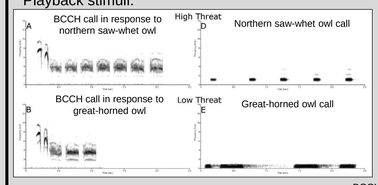
Songbirds are used as a model to examine neurobiological basis of communication.

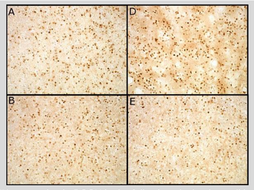
We use the immediate early gene (IEG) ZENK to examine gene expression in response to conspecific (same species) & heterospecific (different species) vocalizations.

Studies from the SNL have found:

- Vocalization type (call or song), sex of producer, & sex of perceiver affect IEG expression .
- Information contained with a vocalization (i.e., degree of threat) affects IEG expression, regardless of whether the signal is produced by a conspecific or heterospecific

Playback stimuli:





ZENK expression in BCCH in the following playback conditions:
BCCH calls produced in response to northern saw-whet owl (*top left*)
BCCH calls produced in response to great-horned owl (*bottom left*)
northern saw-whet call (*top right*)
great-horned owl call (*bottom right*)

Figures from Avey et al. (2011). *PLoSONE.*

Selected publications from SNL:

Publications on *chick-a-dee* calls:

Avey MT, Hoeschele M, Moscicki MK, Bloomfield, LL, Sturdy CB (2011). Neural correlates of threat perception: Neural equivalence of conspecific and heterospecific mobbing calls is learned. *PLoS ONE, 6*(8), e23844

Bloomfield LL, Sturdy CB (2008a). All "chick-a-dee" calls are not created equally. Part I: Open-ended categorization of chick-a-dee calls by sympatric and allopatric chickadees. *Behavioural Processes, 77,* 73-86.

Bloomfield LL, Farrell TM, Sturdy, CB (2008b). All "chick-a-dee" calls are not created equally. Part II: Mechanisms for discriminations by sympatric and allopatric chickadees. *Behavioural Processes, 77,* 87-99.

Guillette LM, Farrell TM, Hoeschele M, Sturdy CB (2010) Acoustic mechanisms of a species-based discrimination of the chick-a-dee call in sympatric black-capped (*Poecile atricapillus*) and mountain chickadees (*P. gambeli*). *Frontiers in Comparative Psychology, 1:229.*

Publications on *fee-bee* songs:

Hahn AH, Guillette LM, Hoeschele M, Mennill DJ, Otter KA, Grava T, Ratcliffe LM, Sturdy CB (In press 21 June 2013). Dominance and geographic information contained within black-capped chickadee (*Poecile atricapillus*) song. To appear in *Behaviour*

Hahn AH, Krysler A, Sturdy CB (2013). Female song in black-capped chickadees (*Poecile atricapillus*): Acoustic song features that contain individual identity information and sex difference. *Behavioural Processes, 98*, 98-105

Hoeschele M, Guillette LM, Sturdy CB (2012). Biological relevance of acoustic signal affects discrimination performance in a songbird. *Animal Cognition, 15,* 677-688.

Hoeschele M, Moscicki MK, Otter KA, van Oort H, Fort KT, Farrell TM, Lee H, Robson SWJ, Sturdy CB (2010). Dominance signalled in an acoustic ornament. *Animal Behaviour, 79,* 657-664.

Acknowledgments

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Range maps from birdsource.org