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This document is part of a collection that serves two purposes. First it is a public archive for data and documents resulting from evolutionary, ecological, and behavioral research conducted by the Ketterson-Nolan research group. The focus of the research is an abundant North American songbird, the dark-eyed junco, *Junco hyemalis*, and the primary sources of support have been the National Science Foundation and Indiana University. The research was conducted in collaboration with numerous colleagues and students, and the objective of this site is to preserve not only the published products of the research, but also to document the organization and people that led to the published findings. Second it is a repository for the works of Val Nolan Jr., who studied songbirds in addition to the junco: in particular the prairie warbler, *Dendroica discolor*. This site was originally compiled and organized by Eric Snajdr, Nicole Gerlach, and Ellen Ketterson.

Context Statement
This document was generated as part of a long-term biological research project on a songbird, the dark-eyed junco, conducted by the Ketterson/Nolan research group at Indiana University. For more information, please see IUScholarWorks (https://scholarworks.iu.edu/dspace/handle/2022/7911).

Differences in structure and tempo of low-amplitude song affect male aggressive response in Dark-eyed Juncos

Carla C. Vanderbilt, Department of Biology, Stetson University, DeLand, FL
Dustin G. Reichard and Ellen D. Ketterson, Department of Biology, Indiana University, Bloomington, IN

Introduction

Long-range song (LRS) is a **high-amplitude,** acoustic signal produced by songbirds that typically functions in territoriality and mate attraction. **Short-range song** (SRS), in contrast, is an often more complex, **low-amplitude** signal that is produced by many species during close-proximity interactions associated with courtship or aggression.

Male Dark-eyed Juncos (*Junco hyemalis*) sing both LRS (Figure 1A) and SRS. In the junco, LRS is sometimes produced at low amplitude (soft LRS), and SRS can be sung in two distinctly different tempos: slow SRS (Figure 1B) and fast SRS (Figure 1C). In a previous study, playbacks of soft LRS elicited the same response as typical LRS. **To investigate the relationship of signal content and function between fast and slow SRS in the Dark-eyed Junco**, we asked the following questions:

1) Will the tempo of the SRS playback have a significant effect on a male's response when his mate is non-fertile?
2) Will SRS playbacks elicit a similar, stronger, or weaker aggressive response compared to soft LRS when the male's mate is non-fertile?

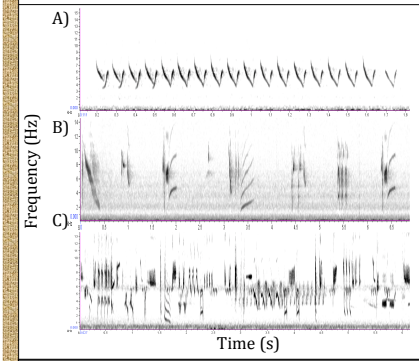

Figure 1. Three different song classes in the Dark-eyed Junco: long-range song (A), slow short-range song (B), and fast short-range song (C).

Methods

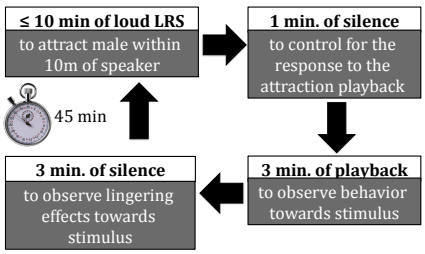

Figure 2. Design of playback experiment on male Dark-eyed Juncos when mates were non-fertile. The cycle was repeated two times at 45 minute intervals until each focal male had received each of the three playback treatments (soft LRS, slow SRS, and fast SRS). Playbacks were randomized and played at a standardized amplitude of 65 dB.

Data Analysis

- **Principal component analysis** (PCA)
  - -Combined eight behavioral responses to create composite response scores for each individual and treatment
- Linear mixed model to control for repeated sampling and treatment order

Results

- **Fast SRS** playbacks generally elicited a **stronger response** than soft LRS playbacks (Figures 3, 4 A-B).
- Response toward **fast SRS and slow SRS never detectably differed** (Figures 3, 4 A-B).

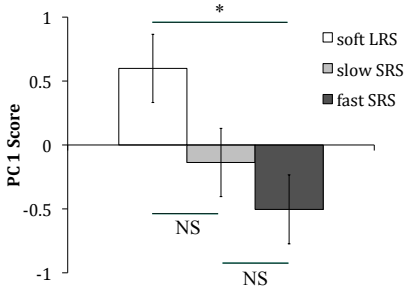

Figure 3. The estimated marginal means of PC1 scores during playback. Error bars represent ± 1 SEM. A more positive PC score is indicative of a stronger behavioral response.

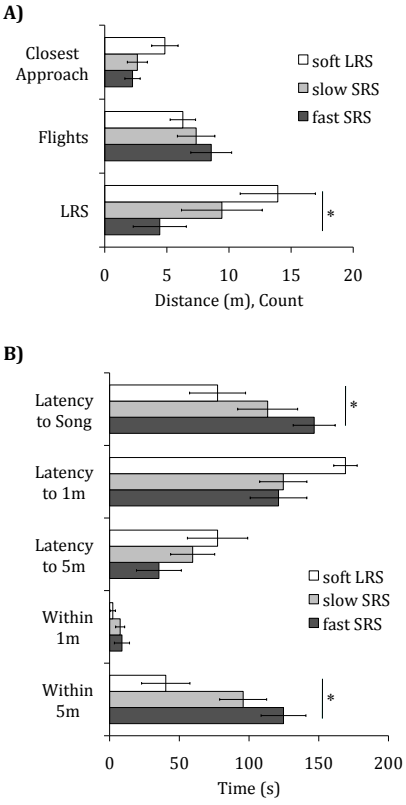

Figure 4 A-B. Mean behavioral responses to each playback treatment. Error bars represent ± 1 SEM. Juncos **took longer to start singing, sang less**, and **spent more time within 5 m** when played fast SRS instead of LRS, which are all behaviors that suggest a stronger response.

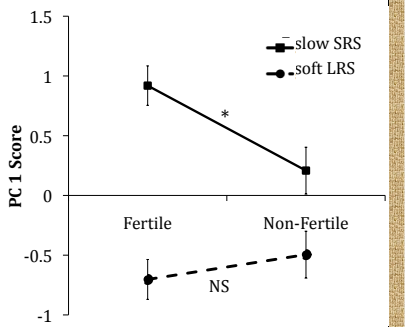

Figure 5. The estimated marginal means comparing response when mates were non-fertile (2010) to response when mates were fertile (2009)(in Reichard *et al.*, 201x). Error bars represent ± 1 SEM. A more positive PC score is indicative of a stronger response. Male juncos had a **stronger response toward slow SRS when mates were fertile**. There **was no difference in response toward LRS** between years.

Conclusions

- **The similarity in response to slow and fast SRS suggests that both tempos may function in courtship or aggression.** The significant difference between fast SRS and soft LRS, but not slow SRS and soft LRS, may indicate that tempo is a graded signal in SRS.
- **Slow SRS likely functions in courtship** because response to slow SRS was higher when the male's mate was fertile than when the mate was non-fertile (Figure 5).
- **Further studies** should determine whether there is variation in male response to LRS, slow SRS, and fast SRS depending on the female's reproductive status within a single year. Experiments examining the effect of fast SRS and slow SRS on female preference would help us to learn more about the possible role of these song classes in courtship.

Literature Cited

Reichard DG, Rice RJ, Vanderbilt CC, Ketterson ED. 201x. Deciphering information encoded in birdsong: male songbirds with fertile mates respond most strongly to complex, low-amplitude songs used in courtship. American Naturalist, in press.

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