

# LATE SOCIAL INFLUENCE ON CRYSTALLIZATION IN A WILD HOUSE FINCH

Frances C. Geller, Chenghui Ju and David C. Lahti

Department of Biology, Queens College, CUNY, Flushing, NY 11367

The CUNY Graduate Center, New York, NY 10016



## BACKGROUND

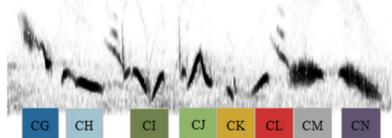
The timing of learning and ontogeny of singing behavior have long been subjects of interest in the study of oscine songbirds. While extensive research has been devoted to the process of crystallization in a laboratory setting, little is known about how social influences drive crystallization in the wild, especially in non-territorial species.

We observed the singing behavior of two male house finches that were flocking together—one adult and one yearling—over two full days one month apart, recording each bout sung from a focal group of trees on the Queens College campus. We then characterized the degree of crystallization of the yearling's repertoire on each day, and tested for its convergence with that of the adult in both phoneme composition and sequence.

## ANALYSIS

**We treated each day's worth of songs produced by the yearling as a structured population of distinct song themes.**

Unique phoneme codes assigned by eye:



Phoneme code sequences representing each full song:



We performed pairwise alignments to generate a similarity score for each pair of songs within the population, using an adapted affine gap penalty method. These scores were then converted to a distance matrix, which was subjected to cluster analysis to assess the degree of song theme crystallization.

Typical pairwise alignment with gap penalties:

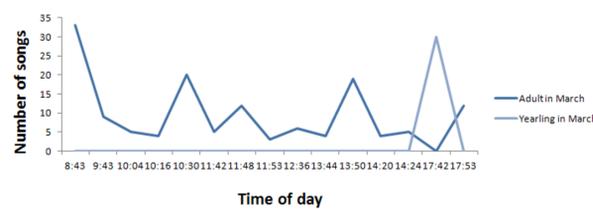


**Similarity Score =**

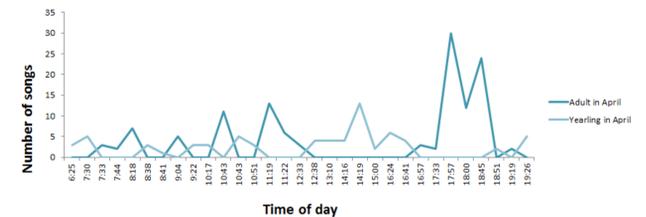
$$\frac{(\text{match score} - (\sum \text{gap penalty} * (1/2)^{\text{gap length}-1}))}{\text{maximum possible match score}}$$

## RESULTS

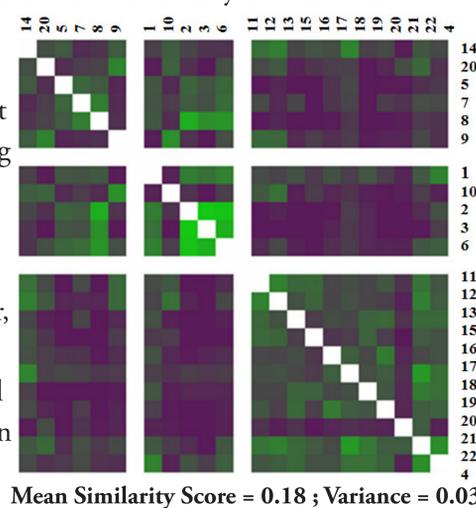
MARCH 21



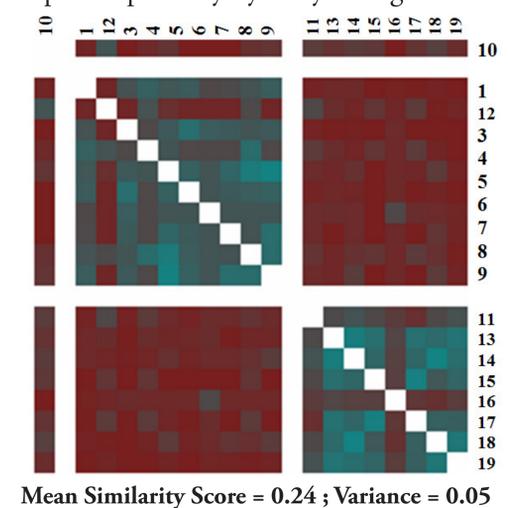
APRIL 25



The adult sang its four stable song themes throughout the day, while the yearling sang only a single bout from the focal site, when the adult was away foraging (frequent agonistic encounters may have had an inhibitory effect). There were consistent patterns among the 22 songs recorded from the yearling's bout. However, no two were identical, so all 22 were used in our analysis.



Both the adult and the yearling sang steadily throughout the day from the focal site. Of the 19 distinct song variants we identified for use in our analysis, many were repeated precisely by the yearling one or more times over the day. Even among these variants, pairwise similarity scores were higher than in March, suggesting stabilization of phoneme sequences.

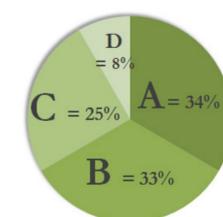
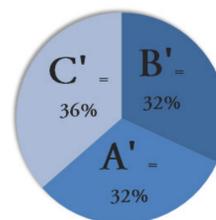


**Above Left and Right:** Heatmaps produced by k-medoid clustering of the distance matrices we generated for the 22 plastic songs the yearling sang in March, and the 19 distinct variants he sang in April. Clustering of song themes was considerably more pronounced in April.

MARCH 21

Phonemes shared by yearling and adult = 29%

Theme proportions were roughly equal for both birds.



**Above:** Green charts show the proportion of each stable theme sung by the adult in March and April. Blue charts show the proportions of variants of those themes sung by the yearling.

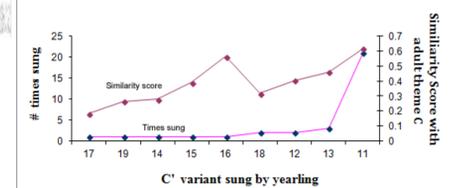
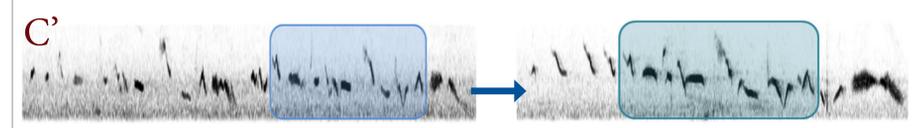
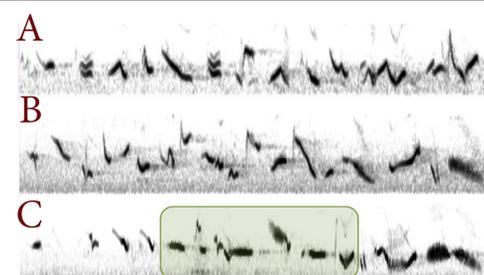
APRIL 25

Phonemes shared by yearling and adult = 43%

Both birds displayed a preference for theme C, suggesting possible context-dependence of different themes. Moreover, the yearling strongly preferred the variant of theme C that most closely matched the adult (illustrated below).

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Stable adult song themes (right) and variants of theme C that the yearling sang in March, then April (below).



Over one month, the yearling (1) increased the proportion of phonemes shared with its adult neighbor and (2) preferentially sang the song variant most similar to the theme the adult favored (score = 0.62). These results suggest that first-year adult neighbors influence both repertoire composition and phoneme sequence in yearling house finches, despite there being no apparent advantage to song sharing in a non-territorial, non-cooperatively breeding species. Future research will explore the nature of social interactions among house finches, their influences on learning throughout development, and the mechanism by which late learning occurs.

CRYSTALLIZATION

CONVERGENCE

DISCUSSION