**Conclusions**

Number of repeated song notes & motif transition entropy were biased

Some of the note repeats & transitions had circadian rhythms

Their trajectories were different from one another

---

**Number of repeated notes & motif transition entropy**

Motifs (frequently appearing sequences)

\[
X \rightarrow cd
\]

\[
Y \rightarrow efghbin
\]

\[
Z \rightarrow j^na
\]

Motif to motif (or note) transitions

\[
X \rightarrow Y
\]

\[
X \rightarrow Z
\]

\[
a \rightarrow b
\]

---

**Detailed methods**

**Subjects**

Four adult male Bengalese finches (Lonchura striata domestica), age > 120 days post hatching

**Recording**

Each bird was put in a separate sound attenuation box with an LED light and a microphone. All recorded songs were unlabeled songs.

**Notes and bouts extraction**

The recorded sound was band-pass filtered at 1-5 kHz. Sound envelopes were calculated by full wave rectification and low pass filtering at 100 Hz. Envelopes with the envelope larger than manually determined threshold were extracted as song bouts. Short intervals (1-5 s) and short gaps (approx. 5 s) were removed (these lengths were adjusted separately in each subject). Song bouts were defined as sound intervals with length > 2 s with silence < 0.3 s at both ends. (Kanchanak, et al. 2014)

**Note labeling**

Each bout was randomly chosen so that the number of total notes included in the bouts = 512. The notes in the chosen bouts were manually labeled and used as training data for the multi-layered convolutional neural network (Hsu, et al. 2014). Half of the training data were used for parameter learning, and the large parameters were determined so as to maintain the classification error in the other half. Then the rest notes were labeled by the trained neural network. All labels were manually checked and (if necessary) modified according to the visual inspection of the spectrum. To validate the appropriateness of the classification with manual label modification, two fold cross validation was performed. The classification error in the cross validation was 0.15%.

---

**Number of repeated notes & transition entropy**

Motifs were extracted manually. The amount of the notes that did not belong to any motifs or introductory parts was < 1% of the total number. Number of repeated notes in each month were counted separately and averaged over 3 hour time window. If a motif has more than one consecutive motifs or notes, transition entropy in 3 hour time window was calculated. The transitions with each frequency > 0% was ignored.

**Detection of bias**

To test if there is a bias in the number of repeated notes or transition entropy, bouts were randomly permuted. Then the number of repeated notes and transition entropy were calculated according to the permuted samples. If the actual values were outside of the 95% range in which the values calculated from permuted samples were distributed, the values were considered to be biased at the time. The number of permuted samples was 2,000.

**Correlation analysis**

To evaluate if there were circadian rhythms in the number of repeated notes or transition entropy, the average correlation coefficients between the values in pairs of days were calculated. This bout in each day were circular shifted with random amount of time. The number of repeated notes or transition entropy was considered to have circadian rhythm if the average correlation coefficients were larger than 0.95% of those in circular shifted samples. The number of circular shifted samples was 20,000.