Using Hawkes process models to assess behavioral motivations to sing, applied in a fragmented forest landscape

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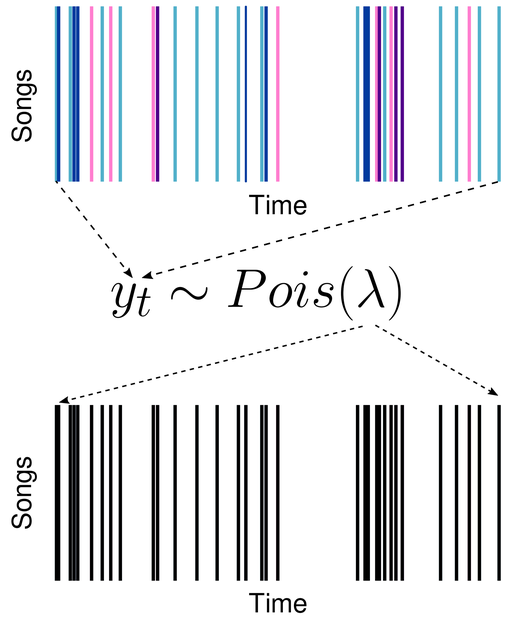
https:://elizagrames.github.io/NAOC2020

Motivations underlying why birds sing can be broken down into two processes:

1) unprompted singing such as attracting a mate (teal) or establishing a territory (pink), and

2) responsive singing such as countersinging (blue) or territory defense (purple).



When singing is modeled as a Poisson process the underlying motivations are treated as a single process and we **lose the ability to understand behavioral motivations.**

Hawkes process models are self-exciting point process models that can be used to fit the underlying motivations for songs as separate processes.

In a Hawkes model, the observed songs (y_t) are drawn from a Poisson process with a variable rate of singing (λ_t),

$$y_t \sim Pois(\lambda_t)$$

which is composed of the background rate of singing (μ) that corresponds to unprompted singing, and a conditional intensity (γ_t) at each timepoint in the time series that corresponds to behaviors associated with responsive singing.

$$\lambda_t = \mu + \gamma_t$$

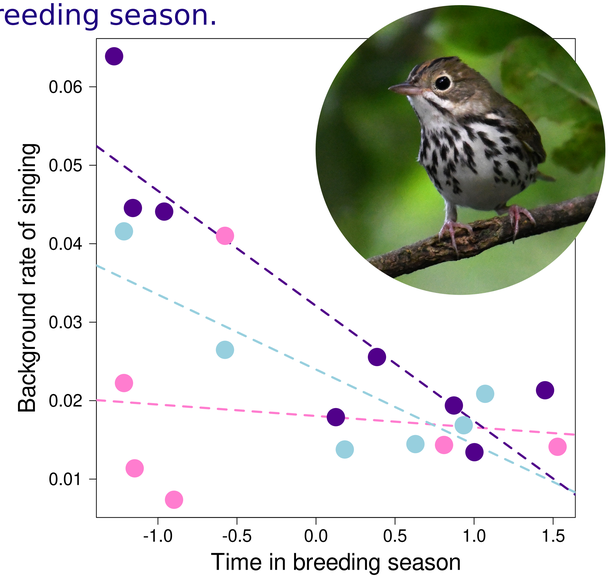
The conditional intensity is a function of motivation to respond to neighbors, or self-excitement (α), which depends on the memory (β) of the history of songs ($\mathcal{H}_t$) leading up to a timepoint.

$$\gamma_t = \alpha \times (e^{-\beta \times \mathcal{H}_t})$$

Breaking down patterns of song into component parts with **a Hawkes model allows us to assess how motivations to sing change in response to environmental factors,** such as time in the breeding season or habitat quality.

As an example, we estimated the background rate of singing (corresponding to territory establishment and mate attraction) for time series of Ovenbird songs from 20 forest patches and fit a linear model of background singing rate as a function of forest patch size and time in breeding season.

Background singing rate declines with time in the breeding season in large (purple) and medium (teal) forests, but remains at a constant low level in small forests (pink), suggesting that males in small forests remain unpaired and continue to sing to attract a mate throughout the breeding season.



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