Study shows that songbirds recognize sound patterns using the overall spectral shape

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Eastern Yellow Robin. Credit: Wikipedia.

(Phys.org)—New research on how songbirds recognize a sound sequence calls into question the prevailing view that songbirds tend to rely on absolute pitch to recognize a song pattern as opposed to humans who tend to rely on relative pitch. Micah R. Bregman, Aniruddh D. Patel, and

Timothy Q. Gentner from the University of California in San Diego and Tufts University demonstrate through behavioral studies that starlings recognize a song pattern by its absolute spectral shape. Their work appears in *The Proceedings of the National Academy of Sciences*.

Songbirds, like humans, can learn sound sequences. They share many common features with human perception of sound and the ability to learn new sounds. However, songbirds perceive sequences of sounds differently. Humans can recognize a sound sequence even if the pitch or timbre changes. For example, most people can recognize "Happy Birthday" whether it is played on an oboe or a trumpet or sung by an alto or soprano. Birds, on the other hand, would not recognize this sound sequence when variations in pitch or timbre occur.

The prevailing thought is that birds recognize song patterns based on the sound sequence's absolute pitch; however, some studies have indicated that there is more to the way birds perceive a sound sequence than pitch. To understand how birds perceive a sound sequence, Bregman, et al. devised an experiment to see how songbirds perceive tone sequences that systematically vary over time in both pitch and timbre.

First, they trained five starlings (*Sturnus vulgaris*) to accurately discern an ascending and descending sound sequence. The starlings were able to distinguish between the ascending and descending sound sequences with over 91% accuracy.

Then, they tested the starlings' ability to recognize a different song sequence that kept the same pitch and timbral pattern as the training sequences. The starlings only correctly identified ascending and descending sequences about 50% of the time, or the same as chance. They were unable to discern even small shifts in pitch. These results seemed to confirm that starlings indeed rely on absolute pitch to recognize a song sequence pattern.

Bregman, et al., then tested the starlings by using a sequence of tones from a novel piano timbre at the same pitch as the two training sequences. If the starlings rely on absolute pitch to identify song sequences, then they should be able to discern the ascending and descending tone sequences that match the training pitch but, in this case, do not match the spectral shape. As it turns out, the starlings did not recognize the song sequences.

Finally, the starlings were tested to see if the spectral shape was kept the same but the absolute pitch was changed, whether they would recognize a song sequence. The spectral shape has to do with the overall pattern of sound frequency amplitudes. By using a noise-vocoder, Bregman, et al. were able to maintain the spectral shape (i.e., the spectral envelope) of the song sequences while changing the pitch. They also tested the starlings using a piano-tone version of the training sequences, which preserves pitch, but it changes the absolute spectral envelope.

In the first 100 trials, the starlings were able to discern the noise-vocoded ascending and descending sound sequences with greater accuracy than chance (approx. 70%). After additional trials, their accuracy increased. The starlings performed comparatively poorer with the piano-toned versions of the training sequences. Statistical comparisons of these results indicate that starlings recognize ascending and descending tone sequences using the absolute spectral envelope as opposed to pitch.

"What our results suggest is that starlings, and probably most songbirds, hear these kinds of sounds in a way that is more similar to how humans hear speech," says Dr. Tim Gentner, principle investigator in this study. "If pressed, you can hear for the pitch of speech, but it's not part of your normal mindset when you are listening to someone speak. Interestingly, if you noise-vocode a piece of music it becomes nearly indecipherable, whereas vocoding speech is noticeable but doesn't destroy comprehension. Like music itself, listening 'musically' is probably a really specialized, learned skill."

This work challenges the view that songbirds rely on absolute pitch to recognize song sequence. In prior studies, the songbirds were tested with simple song sequences, but in this study, they were tested with more complex sequences. In these complex sequences, the spectral envelope plays a key, but not solitary, role in song sequence recognition. This study helps researchers understand important differences between how songbirds generalize sound sequences and how humans generalize sound.

More information: Micah R. Bregman et al. Songbirds use spectral shape, not pitch, for sound pattern recognition, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1515380113

Abstract
Humans easily recognize "transposed" musical melodies shifted up or down in log frequency. Surprisingly, songbirds seem to lack this capacity, although they can learn to recognize human melodies and use complex acoustic sequences for communication. Decades of research have led to the widespread belief that songbirds, unlike humans, are strongly biased to use absolute pitch (AP) in melody recognition. This work relies almost exclusively on acoustically simple stimuli that may belie sensitivities to more complex spectral features. Here, we investigate melody recognition in a species of songbird, the European Starling (Sturnus vulgaris), using tone sequences that vary in both pitch and timbre. We find that small manipulations altering either pitch or timbre independently can drive melody recognition to chance, suggesting that both percepts are poor descriptors of the perceptual cues used by birds for this task. Instead we show that melody recognition can generalize even in the absence of pitch, as long as the spectral shapes of the constituent tones are preserved. These results challenge conventional views regarding the use of pitch cues in nonhuman auditory sequence

recognition.