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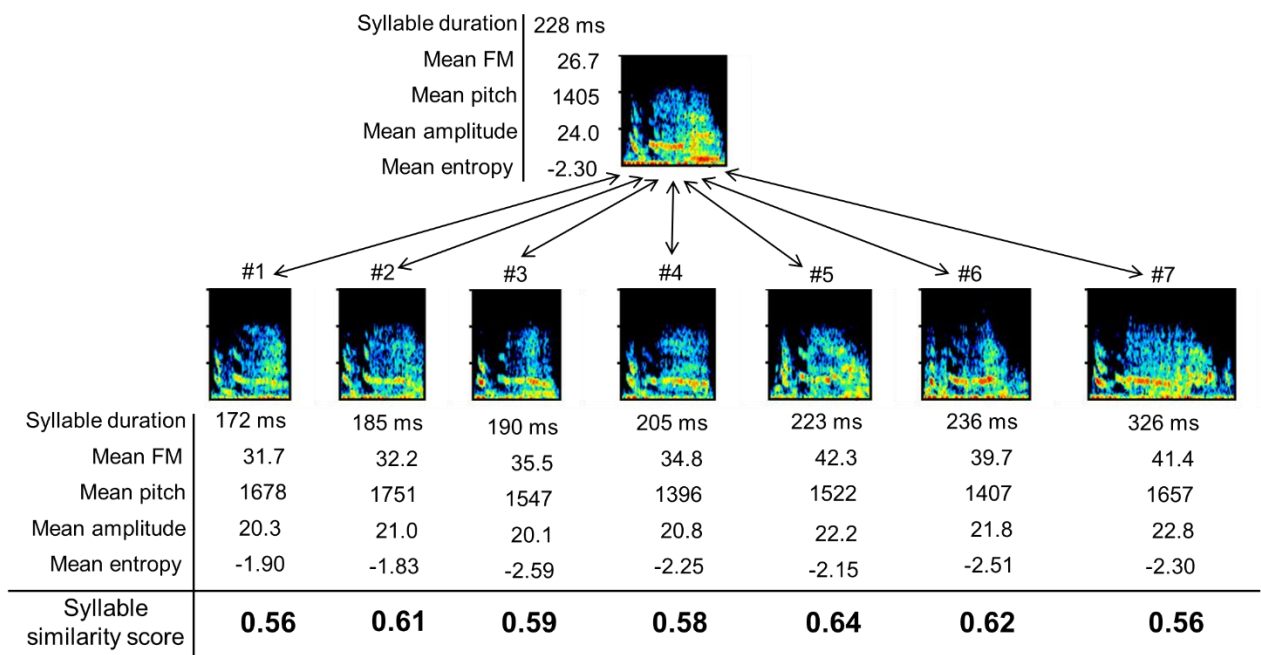|	
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Author(s)	Imai, Raimu; Sawai, Azusa; Hayase, Shin; Furukawa, Hiroyuki; Asogwa, Chinweike Norman; Sanchez, Miguel; Wang, Hongdi; Mori, Chihiro; Wada, Kazuhiro
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Supplementary materials

A quantitative method for analyzing species-specific vocal sequence pattern and its developmental dynamics

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Syllable duration	228 ms						
Mean FM	26.7						
Mean pitch	1405						
Mean amplitude	24.0						
Mean entropy	-2.30						

	#1	#2	#3	#4	#5	#6	#7
Syllable duration	172 ms	185 ms	190 ms	205 ms	223 ms	236 ms	326 ms
Mean FM	31.7	32.2	35.5	34.8	42.3	39.7	41.4
Mean pitch	1678	1751	1547	1396	1522	1407	1657
Mean amplitude	20.3	21.0	20.1	20.8	22.2	21.8	22.8
Mean entropy	-1.90	-1.83	-2.59	-2.25	-2.15	-2.51	-2.30
Syllable similarity score	**0.56**	**0.61**	**0.59**	**0.58**	**0.64**	**0.62**	**0.56**

Supplementary material 1

An example of comparisons of syllable similarity scores between syllables with a variety of durations and other acoustic features taken from a plastic song at the juvenile stage

$$\begin{array}{|c|c|} \hline a & b \\ \hline c & d \\ \hline \end{array}$$

$\sigma = 0.86$ (as the mean value of same/syllables syllables)
$\rho = 0.33$ (as the mean value of different syllables)

Possible syllable transition type

Type I $\quad t1 = ((a - \rho)^2 + (b - \sigma)^2 + (c - \sigma)^2 + (d - \rho)^2)$

Type II $\quad t2 = ((a - \sigma)^2 + (b - \sigma)^2 + (c - \sigma)^2 + (d - \sigma)^2)$

Type III $\quad t3 = ((a - \rho)^2 + (b - \rho)^2 + (c - \rho)^2 + (d - \rho)^2)$

Type IV $\quad t4 = ((a - \sigma)^2 + (b - \rho)^2 + (c - \rho)^2 + (d - \sigma)^2)$

Type V $\quad t5 = ((a - \rho)^2 + (b - \rho)^2 + (c - \sigma)^2 + (d - \rho)^2)$

Type VI $\quad t6 = ((a - \sigma)^2 + (b - \sigma)^2 + (c - \rho)^2 + (d - \rho)^2)$

Type VII $\quad t7 = ((a - \rho)^2 + (b - \sigma)^2 + (c - \rho)^2 + (d - \rho)^2)$

Type VIII $\quad t8 = ((a - \rho)^2 + (b - \rho)^2 + (c - \rho)^2 + (d - \sigma)^2)$

Type IX $\quad t9 = ((a - \sigma)^2 + (b - \rho)^2 + (c - \sigma)^2 + (d - \rho)^2)$

Type X $\quad t10 = ((a - \rho)^2 + (b - \sigma)^2 + (c - \rho)^2 + (d - \sigma)^2)$

Type XI $\quad t11 = ((a - \rho)^2 + (b - \rho)^2 + (c - \sigma)^2 + (d - \sigma)^2)$

Type XII $\quad t12 = ((a - \sigma)^2 + (b - \sigma)^2 + (c - \rho)^2 + (d - \rho)^2)$

Supplementary material 2

Matching calculation was performed to find the most similar binarized pattern from 12 possible patterns of 2 x 2 cells. Sum of distances from the mean values of similar/same (colored with black, σ) or different (colored with white, ρ) syllables were calculated. A pattern type shown with the smallest value in the 12 patters (t1–12) was determined as the most similar binarized pattern for the 2 x 2 cell.
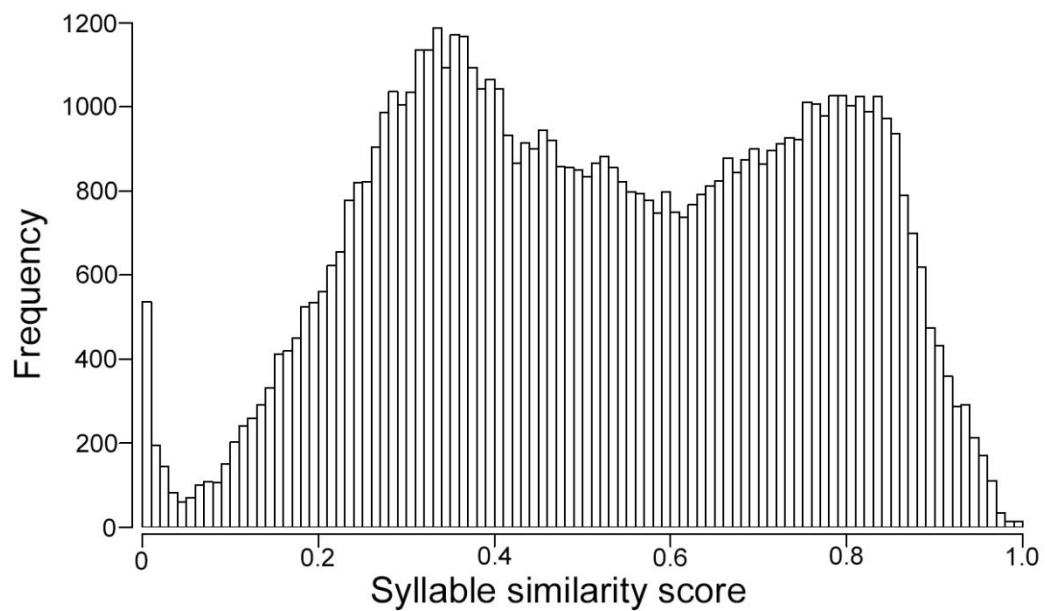
Supplementary material 3

The distribution of syllable similarity scores of 240,000 syllables from six songbird species at the adult stage (ZF, OF, SF, BF, JS, and CN; n = 4 birds/each species, 1000 syllables/bird)
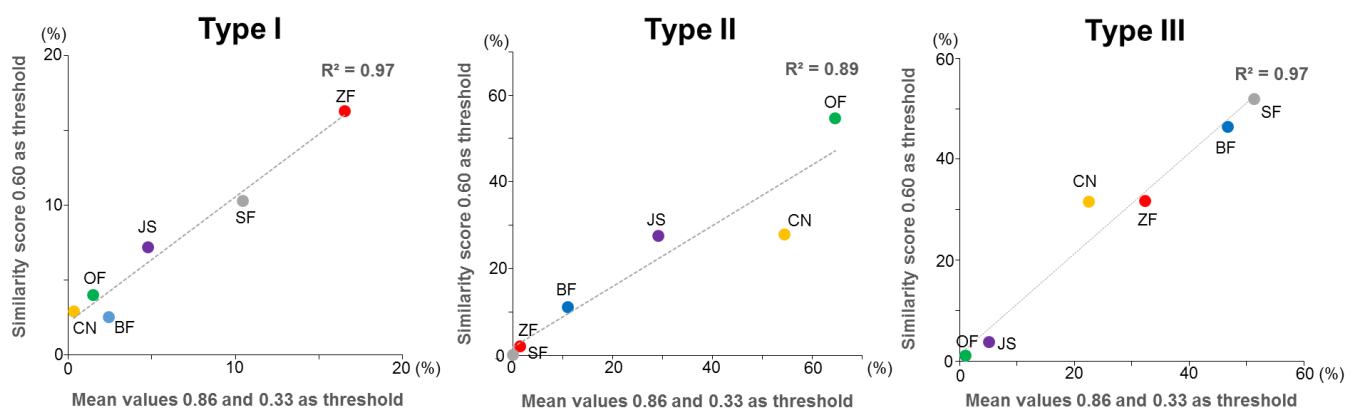
Supplementary material 4

Two different threshold settings for cell binarization - the mean value of 0.86 and 0.33 (as used in this study) or the similarity score 0.60 threshold (as boundary similar and different) - resulted in consistent calculations of the occurrence rates of the syllable transition types I, II, and III. These two threshold settings represented similar values of the occurrence rates of the syllable transition types for individuals of the six species shown in Figure 2.