

Title	Exploring the hidden landscape of female preferences for complex signals
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University College Cork, Ireland Coláiste na hOllscoile Corcaigh Table S1: Description of all of the experimental stimuli. For definitions of variables, see Methods and Fig. 1 in main text. *n* is the sample size of females tested with the set of stimuli referred to on each row. For each row, all factorial combinations of stimuli were tested. Additional controls that were tested for all trials within an experiment are listed at the bottom row of each experiment. In Experiments 1 and 3, in a given experimental session, females were only tested with 2 of the appendage durations, the durations that were paired together are therefore listed on separate rows. Females may have been tested with other sets of stimuli in subsequent testing sessions. 'Base song' refers to the simple calling song stimulus without an appendage.

			Appendage	Appendage delays	Appendage	Base song SI	PL	
	Base song	Appendage type	durations (ms)	(ms)	positions	(dB)		n
Exp.				8, 32, 64, 100, 200,				
1	Standard	Noise	10, 20	300, 400	leading, lagging		70	20
				8, 32, 64, 100, 200,				
	Standard	Noise	40, 80	300, 400	leading, lagging		70	20
				8, 32, 64, 100, 200,				
	Standard	Noise	120, 200	300, 400	leading, lagging		70	20

				8, 32, 64, 100, 200,			
	Standard	Noise	300, 400	300, 400	leading, lagging	70	20
				8, 32, 64, 100, 200,			
	Standard	Noise	500, 600	300, 400	leading, lagging	70	16
				8, 32, 64, 100, 200,			
	Standard	Noise	700, 800	300, 400	leading, lagging	70	17
*Addi no bas	itional contro se song	ls for all trials of Experim	ent 1: 3240 ms noise, si	lence, standard song with	n no appendage, the two appenda	.ges w	<i>'ith</i>
*Addi no bas Exn.	itional contro se song	ls for all trials of Experim	nent 1: 3240 ms noise, si	lence, standard song with	n no appendage, the two appenda	ges w	<sup>,</sup> ith
*Addi no bas Exp. 2	itional contro se song	ls for all trials of Experim	nent 1: 3240 ms noise, si 10, 80, 200, 400, 800	lence, standard song with	h no appendage, the two appenda	.ges w 64	29
*Addi no bas Exp. 2 *Addi append	itional contro se song Shortened itional contro dage, 4 attrac	ls for all trials of Experim Noise ls for all trials of Experim ctive synthetic calling son	nent 1: 3240 ms noise, si 10, 80, 200, 400, 800 nent 2: 3240 ms noise, st gs	lence, standard song with 200 andard song with no app	h no appendage, the two appenda leading, lagging endage, shortened song with no	64	29
*Addi no bas Exp. 2 *Addi append Exp.	itional contro se song Shortened itional contro dage, 4 attrac	Is for all trials of Experim Noise Is for all trials of Experim ctive synthetic calling son	nent 1: 3240 ms noise, si 10, 80, 200, 400, 800 nent 2: 3240 ms noise, st gs	lence, standard song with 200 andard song with no app 8, 32, 64, 100, 200,	h no appendage, the two appenda	64	29

## 8, 32, 64, 100, 200,

Gappy	Noise	40, 80	300, 400	leading, lagging	70	16
			8, 32, 64, 100, 200,			
Gappy	Noise	120, 200	300, 400	leading, lagging	70	17
			8, 32, 64, 100, 200,			
Gappy	Noise	300, 400	300, 400	leading, lagging	70	17

\*Additional controls for all trials of Experiment 3: 3240 ms noise, silence, standard song with no appendage, the two appendages with no base song, 4 attractive synthetic calling songs

Exp.		Synthetic C. b.					
4	Standard	hedickei	810	200	leading, lagging	64	34
	Standard	Synthetic C. brunneus	690	200	leading, lagging	64	34
	Standard	Synthetic C. mollis	600	200	leading, lagging	64	34
		Natural C. b. hedickei					
	Standard	exemplar 1	1936	200	leading, lagging	64	34
	Standard	Natural C. b. hedickei	450	200	leading, lagging	64	34

## exemplar 2

## Natural C. b. hedickei

Standard	exemplar 3	1957	200	leading, lagging	64	34
	Synthetic C. b.					
Shortened	hedickei	810	200	leading, lagging	64	29
Shortened	Synthetic C. brunneus	690	200	leading, lagging	64	29
Shortened	Synthetic C. mollis	600	200	leading, lagging	64	29
	Natural C. b. hedickei					
Shortened	exemplar 1	1936	200	leading, lagging	64	34
	Natural C. b. hedickei					
Shortened	exemplar 2	450	200	leading, lagging	64	34
	Natural C. b. hedickei					
Shortened	exemplar 3	1957	200	leading, lagging	64	34

\*Additional controls for Experiment 4: 3240 ms noise, standard song with no appendage, shortened song with no appendage,

heterospecific appendages without base song, 4 attractive synthetic calling songs

Table S2: Details of the natural *C. b. hedickei* appendage stimuli used in Experiment 4. The
natural *C. b. hedickei* appendage stimuli were obtained from recordings kindly provided by
Frieder Meyer, Museum für Naturkunde, Berlin. To generate the stimuli used for playbacks,
these recordings were digitized, and the amplitude envelope of the digitized natural appendage
was then extracted and filled with filtered white noise (4.0-40 kHz) using custom software
provided by R. Matthias Hennig.



		8		
Stimulus	<b>Recording Location</b>	Temperature (°C)	Date	Recorded by:
Natural	Hungary, Budapest,			
exemplar 1	Szechenyi-mountain	unknown	unknown	unknown
Natural			28-31 July	KG. Heller &
exemplar 2	Kosovo, Sar planina	23-24	1979	M. Volleth
			07	
Natural			August	
exemplar 3	Slovakia	32	2004	F. Mayer

Recording

Table S3: Results of generalized linear mixed models testing effects of appendage and song characteristics on the absolute proportion 18 of response to each stimulus. In the main text, our graphical presentations and statistical analyses were based on measures of the 19 differences between the female's response to each complex appendage stimulus and its response to the corresponding simple stimulus 20 (either the standard or shortened song, depending on the experiment). Here, we present the results of analyses of the absolute response 21 data, not taken in reference to any particular stimulus. We measured a female's response as the proportion of presentations of a given 22 23 stimulus to which she gave a response song out of the total number of presentations of that stimulus. We analyzed these data statistically using generalized linear mixed models. The response variable was a list containing the number of stimulus presentations 24 in which the female responded and a term for the total number of times a female was exposed to that stimulus. This was modeled as a 25 binomial variable (logit link function) using the glmer function in the lme4 package (version 1.1-10; Bates et al. 2015) in R 3.2.2 26 27 software (R development Core Team, 2015). Otherwise, models were constructed and assessed using the same procedures described for the analyses in the main text. Only the final models after the removal of non-significant higher-order interaction terms (see text for 28 details) are shown here. Fixed effects refer to characteristics of appendages, except for song duration, which refers to the duration of 29 the song itself and was modeled as a categorical fixed effect with two levels (standard and shortened song, standard is the reference 30 category). Position is modeled as a categorical fixed effect with two levels (lagging and leading appendage position, lagging is the 31 reference category). Significant *P* values are highlighted in bold. 32

33

Experiment	Fixed effect	Parameter estimate ( $\pm$ SE)	Z	Р
1. Noise appendage, standard song	Intercept	$0.45\pm0.11$	4.1	<0.001
	Duration	$-4.08 \times 10^{\text{-4}} \pm 1.95 \times 10^{\text{-4}}$	-2.1	0.03
	Delay	$-6.58 \times 10^{\text{-4}} \pm 3.62 \times 10^{\text{-4}}$	-1.8	0.07
	Position	$0.060\pm.045$	1.34	0.18
	Duration <sup>2</sup>	$-3.05\times 10^{\text{-7}}\pm 2.47\times 10^{\text{-7}}$	-1.24	0.22
	Delay <sup>2</sup>	$1.90 \times 10^{7} \pm 8.64 \times 10^{7}$	0.22	0.83
	Duration × delay	$7.17 \times 10^{7} \pm 2.42 \times 10^{7}$	3.0	0.003
	Duration $\times$ position	$-2.44 \times 10^{\text{-3}} \pm 2.45 \times 10^{\text{-4}}$	-10.0	<0.001
	$Delay \times position$	$\text{-}1.59 \times 10^{\text{-}3} \pm 5.07 \times 10^{\text{-}4}$	-3.1	0.002
	Duration <sup>2</sup> × position	$1.34 \times 10^{\text{-6}} \pm 3.19 \times 10^{\text{-7}}$	4.2	<0.001
	$Delay^2 \times position$	$3.11 \times 10^{\text{-6}} \pm 1.24 \times 10^{\text{-6}}$	2.5	0.012
2. Noise appendage, shortened song	Intercept	$-0.528 \pm 0.214$	-2.5	0.014
	Duration	$0.015\pm0.044$	0.34	0.74
	Position	$-0.895 \pm 0.069$	-13.0	<0.001

	Duration × position	$-0.392 \pm 0.071$	-5.5	<0.001
3. Noise appendage, gappy song	Intercept	$-3.2 \pm 0.28$	-11.4	<0.001
	Duration	$8.20 \times 10^{\text{-3}} \pm 7.61 \times 10^{\text{-4}}$	10.8	<0.001
	Delay	$-7.30 \times 10^{\text{-4}} \pm 5.27 \times 10^{\text{-4}}$	-1.4	0.17
	Position	$-1.23 \times 10^{-2} \pm 7.82 \times 10^{-2}$	-0.16	0.88
	Duration <sup>2</sup>	$\textbf{-1.99}\times10^{\textbf{-5}}\pm1.87\times10^{\textbf{-6}}$	-10.6	<0.001
	Delay <sup>2</sup>	$2.03 \times 10^{\text{-6}} \pm 1.25 \times 10^{\text{-6}}$	1.6	0.11
	Duration × position	$-2.88 \times 10^{\text{-3}} \pm 1.02 \times 10^{\text{-3}}$	-2.82	0.005
	$Delay \times position$	$-9.42 \times 10^{-4} \pm 2.55 \times 10^{-4}$	-3.69	<0.001
	$Duration^2 \times position$	$5.27 \times 10^{\text{-6}} \pm 2.59 \times 10^{\text{-6}}$	2.04	0.04
4. Synthetic heterospecific appendage	Intercept	$0.579 \pm 0.227$	2.6	0.011
	Species (C. b. hedickei)	$-0.073 \pm 0.230$	-0.3	0.75
	Species (C. mollis)	$0.118 \pm 0.119$	1.0	0.32
	Position	$-1.07 \pm 0.12$	-8.97	<0.001
	Song duration	$-1.20 \pm 0.33$	-3.6	<0.001

	Position x song duration	$-0.313 \pm 0.152$	-2.1	0.039
	Position x species (C. b. hedickei)	$0.323\pm0.205$	1.6	0.11
	Position x species (C. mollis)	$-0.068 \pm 0.146$	-0.5	0.64
	Song duration x species (C. b. hedickei)	$0.272\pm0.200$	1.4	0.17
	Song duration x species (C. mollis)	$-0.060 \pm 0.147$	-0.41	0.68
5. Natural C. b. hedickei appendage	Intercept	$1.31 \pm 0.19$	6.9	<0.001
	Exemplar 2	$-0.464 \pm 0.116$	-4.0	<0.001
	Exemplar 3	$-0.574 \pm 0.116$	-5.0	<0.001
	Position	$-0.405 \pm 0.109$	-3.7	<0.001
	Song duration	$-1.09 \pm 0.11$	-10.1	<0.001
	Position $\times$ song duration	$0.486\pm0.106$	4.6	<0.001
	Position $\times$ exemplar 2	$-0.046 \pm 0.130$	-0.4	0.72
	Position $\times$ exemplar 3	$0.071 \pm 0.130$	0.5	0.58
	Song duration $\times$ exemplar 2	$-0.166 \pm 0.130$	-1.3	0.20
	Song duration $\times$ exemplar 3	$-0.196 \pm 0.130$	-1.5	0.13

36 Figure S1: Responses of females in Experiment 1 to complex songs with noise appendages of 37 varying duration, appended to the standard song stimulus. Appendages were placed either after the song (lagging appendages, open circles) or before the song (leading appendages, filled 38 39 circles) with a delay of 8 ms. Each point shows the mean of the differences between each female's response to the complex stimulus with the appendage duration indicated by the x-axis 40 value, and its response to the standard song, which had no appendage. Female response was 41 42 measured as the proportion of stimulus repetitions to which she emitted a response song. Error bars represent 95% confidence intervals of the mean. Sample sizes are given in Table S1. Lines 43 are cubic splines calculated from general additive models on the mean response values (see 44 Methods, main text, for more details) to enable visualisation of the shape of the preference 45 functions for appendage duration. The smoothing parameter was selected using the model 46 algorithm with the constraint that it must be greater than 0.05. Solid line, leading appendages; 47 dashed line, lagging appendages. 48



Figure S2: Responses of females in Experiment 1 to complex songs with noise appendages of
varying duration, appended to the standard song stimulus with a delay of 32 ms. Interpretation
as in Figure S1.





Figure S3: Responses of females in Experiment 1 to complex songs with noise appendages of
varying duration, appended to the standard song stimulus with a delay of 64 ms. Interpretation
as in Figure S1.



Figure S4: Responses of females in Experiment 1 to complex songs with noise appendages of
varying duration, appended to the standard song stimulus with a delay of 100 ms. Interpretation
as in Figure S1.



Figure S5: Responses of females in Experiment 1 to complex songs with noise appendages of
varying duration, appended to the standard song stimulus with a delay of 200 ms. Interpretation
as in Figure S1.





/ 5

Figure S6: Responses of females in Experiment 1 to complex songs with noise appendages of
varying duration, appended to the standard song stimulus with a delay of 300 ms. Interpretation
as in Figure S1.



Figure S7: Responses of females in Experiment 1 to complex songs with noise appendages of
varying duration, appended to the standard song stimulus with a delay of 400 ms. Interpretation
as in Figure S1.



Figure S8: Responses of females to the noise appendage stimuli. For these stimuli, the noise appendage was presented in isolation, without any base calling song. Dotted line represents response to the negative control, a 3.24 s noise stimulus (n = 180). Numbers above bars indicate sample sizes (this figure combines data from females in Experiments 1 and 3 because these stimuli were presented to females in both experiments). Bar height represents mean response (the mean proportion of stimulus repetitions to which females emitted a response song); error bars represent 95% confidence intervals of the mean. Sample sizes are given in Table S1.



93

Figure S9: Responses of females in Experiment 3 to complex songs with noise appendages of
varying duration, appended to the gappy song stimulus with a delay of 8 ms. Interpretation as in
Figure S1. Sample sizes are given in Table S1.



Figure S10: Responses of females in Experiment 3 to complex songs with noise appendages of
varying duration, appended to the gappy song stimulus with a delay of 32 ms. Interpretation as
in Figure S1. Sample sizes are given in Table S1.



Figure S11: Responses of females in Experiment 3 to complex songs with noise appendages of
varying duration, appended to the gappy song stimulus with a delay of 64 ms. Interpretation as
in Figure S1. Sample sizes are given in Table S1.



Figure S12: Responses of females in Experiment 3 to complex songs with noise appendages of
varying duration, appended to the gappy song stimulus with a delay of 100 ms. Interpretation as
in Figure S1. Sample sizes are given in Table S1.



Figure S13: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 200 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.



Figure S14: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 300 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.



123

Figure S15: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 400 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.



Figure S16: Responses of females in Experiment 4 to the heterospecific appendage stimuli. For these stimuli, the appendage was presented in isolation, without any base calling song. Dotted line represents the average response to the negative control, a 3.24 s noise stimulus (n = 63). Numbers above bars indicate sample sizes. Otherwise, interpretation of figure as in Figure S8 and Figure 5 in main text.

- 135
- 136

