CORA Cork Open Research Archive
Cartlann Taighde Oscailte Chorcaí

Title	Exploring the hidden landscape of female preferences for complex signals
Authors	Reichert, Michael S.;Finck, Jonas;Ronacher, Bernhard
Publication date	2017-03-01
Original Citation	Reichert, M. S., Finck, J. and Ronacher, B. (2017) 'Exploring the hidden landscape of female preferences for complex signals', Evolution, 71(4), pp. 1009–1024. doi:10.1111/evo.13202
Type of publication	Article (peer-reviewed)
Link to publisher's version	http://dx.doi.org/10.5061/dryad.51g4t/1 - 10.1111/evo.13202
Rights	© 2017 The Authors. Evolution © 2017 The Society for the Study of Evolution. - https://authorservices.wiley.com/author-resources/Journal-Authors/licensing-and-open-access/licensing/onlineopen-without-a-creative-commons-license.html
Download date	2026-10-30 10:16:20
Item downloaded from	https://hdl.handle.net/10468/3973



UCC
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.

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

	Standard	Noise	300, 400	8, 32, 64, 100, 200, 300, 400	leading, lagging	70	20
	Standard	Noise	500, 600	8, 32, 64, 100, 200, 300, 400	leading, lagging	70	16
	Standard	Noise	700, 800	8, 32, 64, 100, 200, 300, 400	leading, lagging	70	17

*Additional controls for all trials of Experiment 1: 3240 ms noise, silence, standard song with no appendage, the two appendages with no base song

Exp. 2	Shortened	Noise	10, 80, 200, 400, 800	200	leading, lagging	64	29

*Additional controls for all trials of Experiment 2: 3240 ms noise, standard song with no appendage, shortened song with no appendage, 4 attractive synthetic calling songs

Exp. 3	Gappy	Noise	10, 20	8, 32, 64, 100, 200, 300, 400	leading, lagging	70	17

	Gappy	Noise	40, 80	8, 32, 64, 100, 200, 300, 400	leading, lagging	70	16
	Gappy	Noise	120, 200	8, 32, 64, 100, 200, 300, 400	leading, lagging	70	17
	Gappy	Noise	300, 400	8, 32, 64, 100, 200, 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
	Standard	Natural *C. b. hedickei* 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.

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

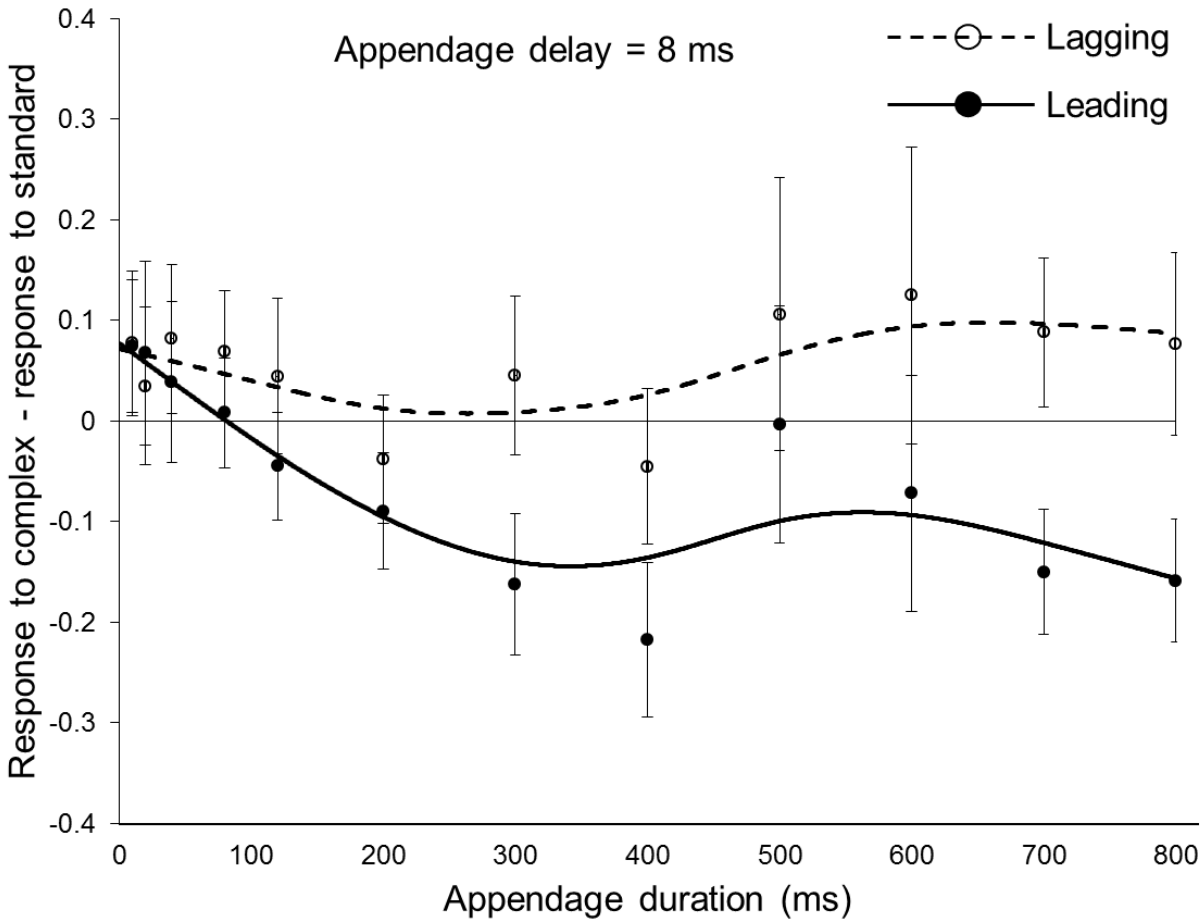
Table S3: Results of generalized linear mixed models testing effects of appendage and song characteristics on the absolute proportion of response to each stimulus. In the main text, our graphical presentations and statistical analyses were based on measures of the differences between the female's response to each complex appendage stimulus and its response to the corresponding simple stimulus (either the standard or shortened song, depending on the experiment). Here, we present the results of analyses of the absolute response data, not taken in reference to any particular stimulus. We measured a female's response as the proportion of presentations of a given 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 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 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 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 details) are shown here. Fixed effects refer to characteristics of appendages, except for song duration, which refers to the duration of the song itself and was modeled as a categorical fixed effect with two levels (standard and shortened song, standard is the reference category). Position is modeled as a categorical fixed effect with two levels (lagging and leading appendage position, lagging is the reference category). Significant *P* values are highlighted in bold.

Experiment	Fixed effect	Parameter estimate (± SE)	*z*	*P*
1. Noise appendage, standard song	Intercept	0.45 ± 0.11	4.1	**<0.001**
	Duration	$-4.08 \times 10^{-4} \pm 1.95 \times 10^{-4}$	-2.1	**0.03**
	Delay	$-6.58 \times 10^{-4} \pm 3.62 \times 10^{-4}$	-1.8	0.07
	Position	$0.060 \pm .045$	1.34	0.18
	Duration^2	$-3.05 \times 10^{-7} \pm 2.47 \times 10^{-7}$	-1.24	0.22
	Delay^2	$1.90 \times 10^{-7} \pm 8.64 \times 10^{-7}$	0.22	0.83
	Duration × delay	$7.17 \times 10^{-7} \pm 2.42 \times 10^{-7}$	3.0	**0.003**
	Duration × position	$-2.44 \times 10^{-3} \pm 2.45 \times 10^{-4}$	-10.0	**<0.001**
	Delay × position	$-1.59 \times 10^{-3} \pm 5.07 \times 10^{-4}$	-3.1	**0.002**
	Duration^2 × position	$1.34 \times 10^{-6} \pm 3.19 \times 10^{-7}$	4.2	**<0.001**
	Delay^2 × position	$3.11 \times 10^{-6} \pm 1.24 \times 10^{-6}$	2.5	**0.012**
2. Noise appendage, shortened song	Intercept	-0.528 ± 0.214	-2.5	**0.014**
	Duration	0.015 ± 0.044	0.34	0.74
	Position	-0.895 ± 0.069	-13.0	**<0.001**

	Duration × position	-0.392 ± 0.071	-5.5	**<0.001**
3. Noise appendage, gappy song	Intercept	-3.2 ± 0.28	-11.4	**<0.001**
	Duration	$8.20 \times 10^{-3} \pm 7.61 \times 10^{-4}$	10.8	**<0.001**
	Delay	$-7.30 \times 10^{-4} \pm 5.27 \times 10^{-4}$	-1.4	0.17
	Position	$-1.23 \times 10^{-2} \pm 7.82 \times 10^{-2}$	-0.16	0.88
	Duration^2	$-1.99 \times 10^{-5} \pm 1.87 \times 10^{-6}$	-10.6	**<0.001**
	Delay^2	$2.03 \times 10^{-6} \pm 1.25 \times 10^{-6}$	1.6	0.11
	Duration × position	$-2.88 \times 10^{-3} \pm 1.02 \times 10^{-3}$	-2.82	**0.005**
	Delay × position	$-9.42 \times 10^{-4} \pm 2.55 \times 10^{-4}$	-3.69	**<0.001**
	Duration^2 × position	$5.27 \times 10^{-6} \pm 2.59 \times 10^{-6}$	2.04	**0.04**
4. Synthetic heterospecific appendage	Intercept	0.579 ± 0.227	2.6	**0.011**
	Species (*C. b. hedickei*)	-0.073 ± 0.230	-0.3	0.75
	Species (*C. mollis*)	0.118 ± 0.119	1.0	0.32
	Position	-1.07 ± 0.12	-8.97	**<0.001**
	Song duration	-1.20 ± 0.33	-3.6	**<0.001**

	Position x song duration	-0.313 ± 0.152	-2.1	**0.039**
	Position x species (*C. b. hedickei*)	0.323 ± 0.205	1.6	0.11
	Position x species (*C. mollis*)	-0.068 ± 0.146	-0.5	0.64
	Song duration x species (*C. b. hedickei*)	0.272 ± 0.200	1.4	0.17
	Song duration x species (*C. mollis*)	-0.060 ± 0.147	-0.41	0.68
5. Natural *C. b. hedickei* appendage	Intercept	1.31 ± 0.19	6.9	**<0.001**
	Exemplar 2	-0.464 ± 0.116	-4.0	**<0.001**
	Exemplar 3	-0.574 ± 0.116	-5.0	**<0.001**
	Position	-0.405 ± 0.109	-3.7	**<0.001**
	Song duration	-1.09 ± 0.11	-10.1	**<0.001**
	Position × song duration	0.486 ± 0.106	4.6	**<0.001**
	Position × exemplar 2	-0.046 ± 0.130	-0.4	0.72
	Position × exemplar 3	0.071 ± 0.130	0.5	0.58
	Song duration × exemplar 2	-0.166 ± 0.130	-1.3	0.20
	Song duration × exemplar 3	-0.196 ± 0.130	-1.5	0.13

Figure S1: Responses of females in Experiment 1 to complex songs with noise appendages of 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 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 value, and its response to the standard song, which had no appendage. Female response was 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 are cubic splines calculated from general additive models on the mean response values (see Methods, main text, for more details) to enable visualisation of the shape of the preference functions for appendage duration. The smoothing parameter was selected using the model algorithm with the constraint that it must be greater than 0.05. Solid line, leading appendages; dashed line, lagging appendages.


Appendage delay = 8 ms
Lagging
Leading
Response to complex - response to standard
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
100
200
300
400
500
600
700
800
Appendage duration (ms)

50

51

52

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.

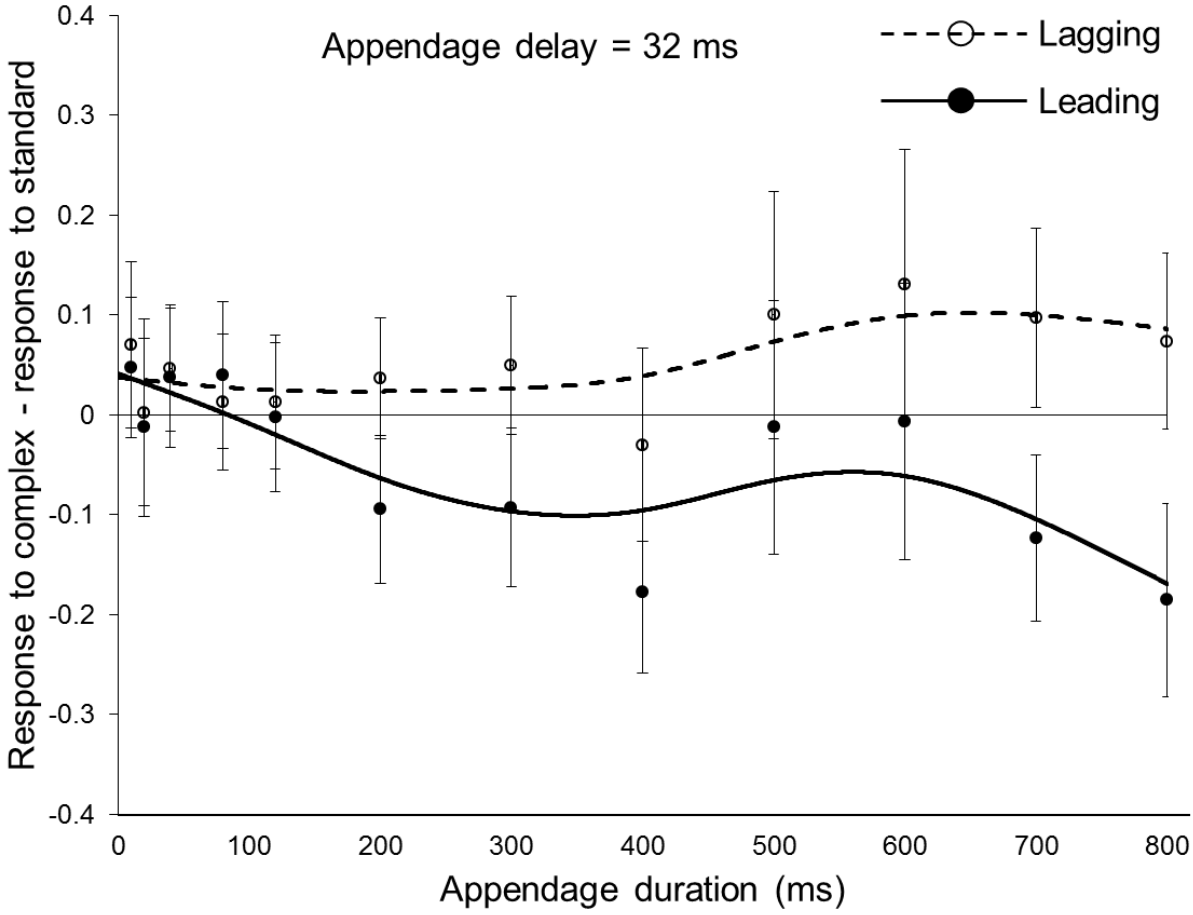


Figure S3: Responses of females in Experiment 1 to complex songs with noise appendages of varying duration, appended to the standard song stimulus with a delay of 64 ms. Interpretation as in Figure S1.

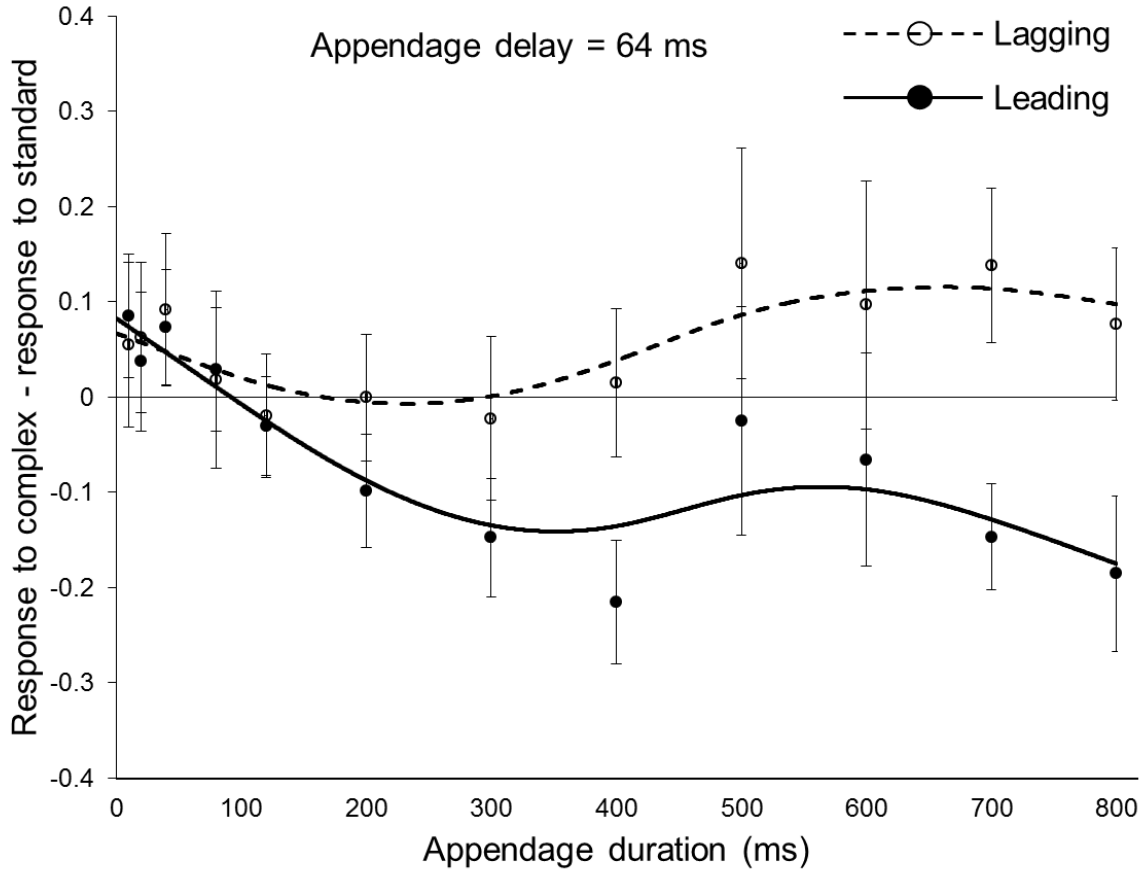


Figure S4: Responses of females in Experiment 1 to complex songs with noise appendages of varying duration, appended to the standard song stimulus with a delay of 100 ms. Interpretation as in Figure S1.

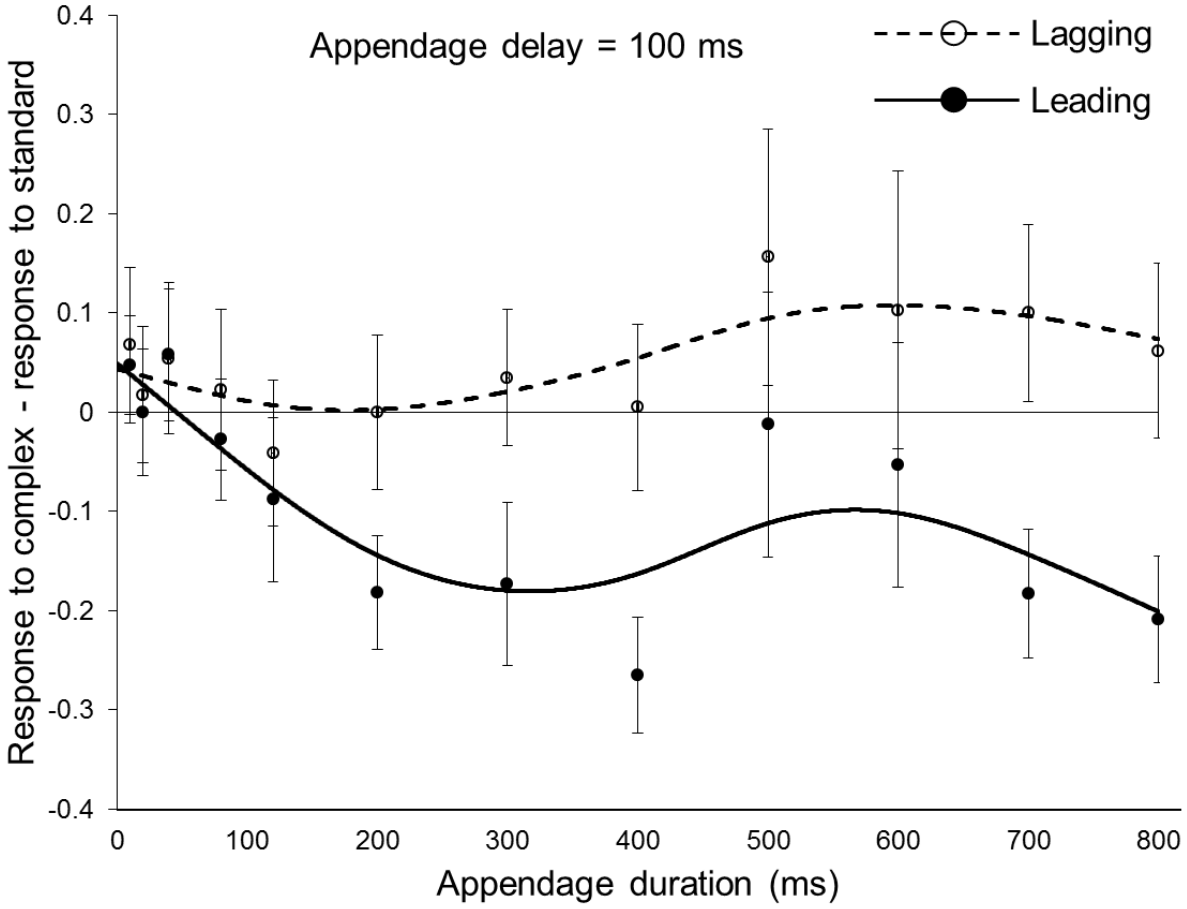


Figure S5: Responses of females in Experiment 1 to complex songs with noise appendages of varying duration, appended to the standard song stimulus with a delay of 200 ms. Interpretation as in Figure S1.

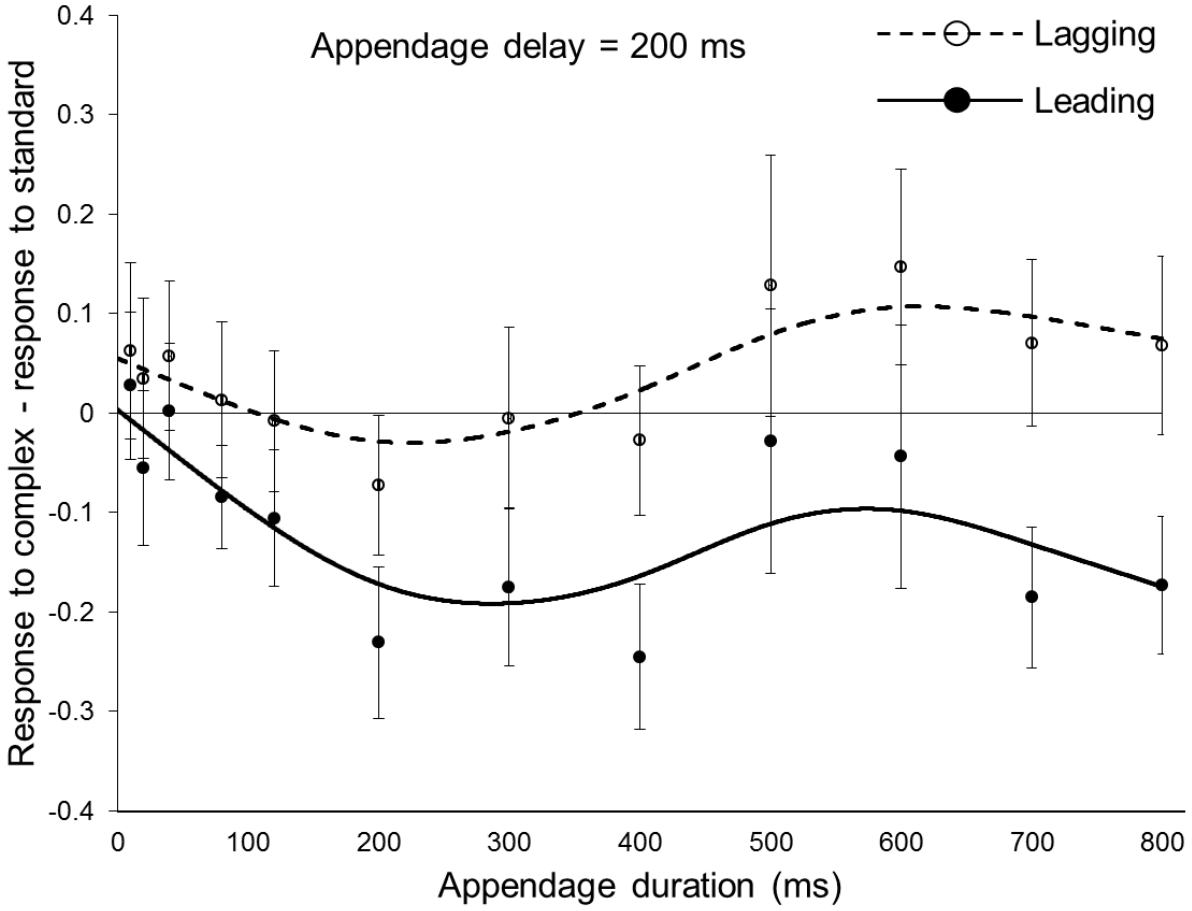


Figure S6: Responses of females in Experiment 1 to complex songs with noise appendages of varying duration, appended to the standard song stimulus with a delay of 300 ms. Interpretation as in Figure S1.

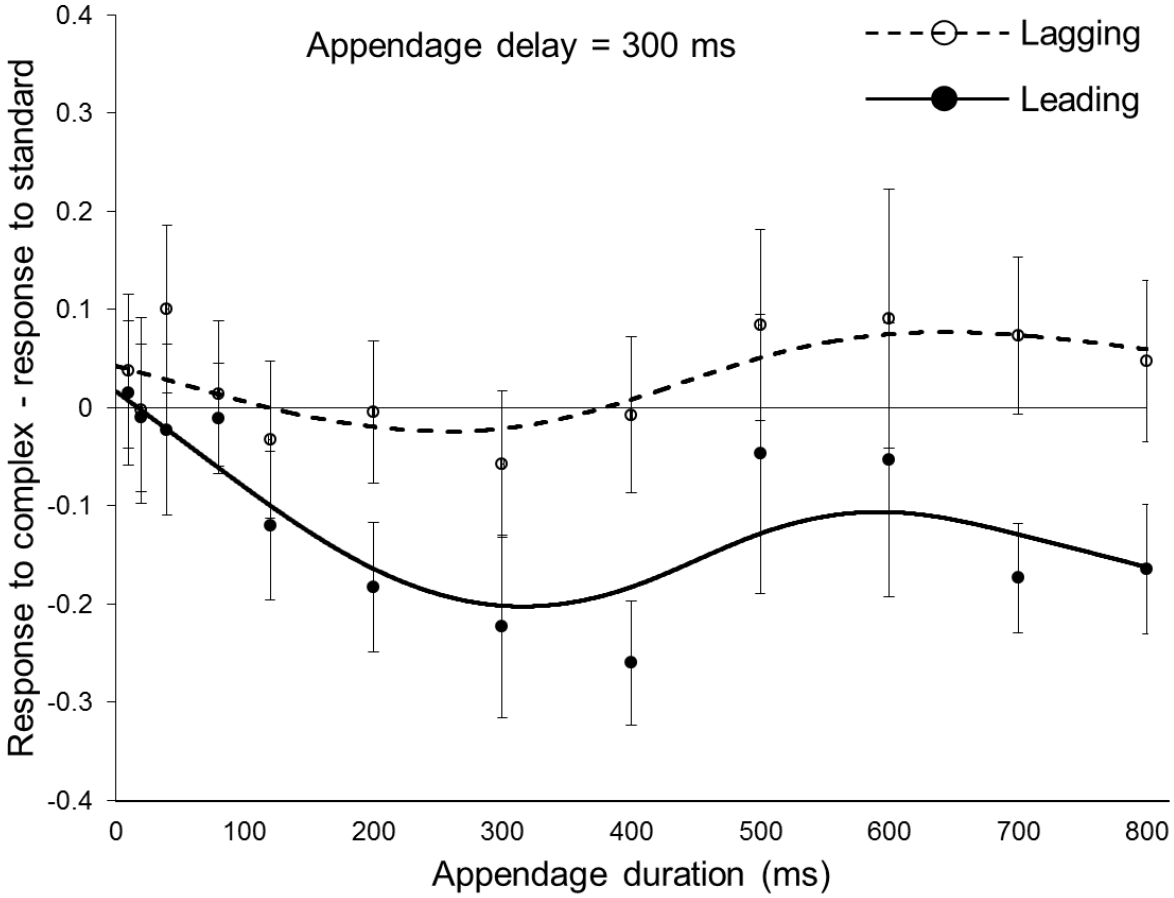


Figure S7: Responses of females in Experiment 1 to complex songs with noise appendages of varying duration, appended to the standard song stimulus with a delay of 400 ms. Interpretation as in Figure S1.

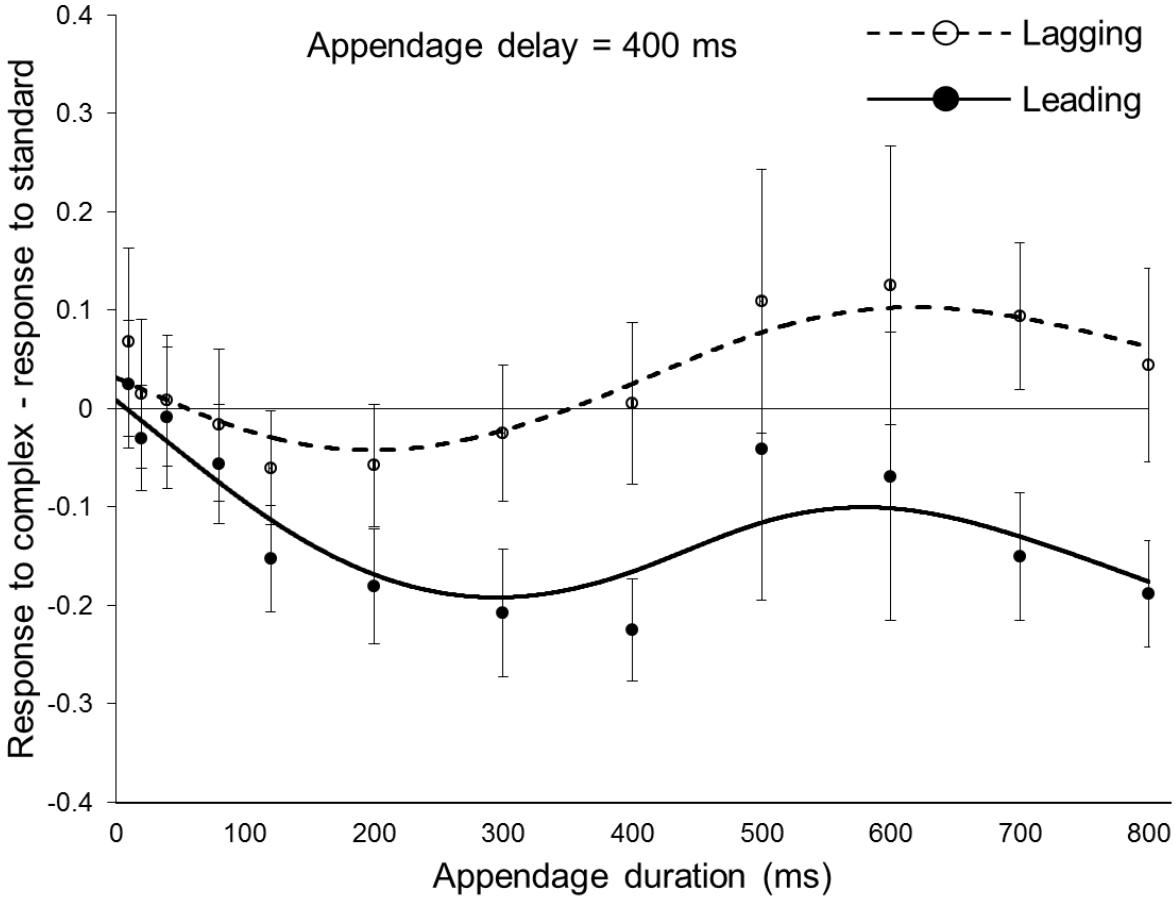


Figure S8: Responses of females to the noise appendage stimuli. For these stimuli, the noise appendage was presented in isolation, without any base calling song. Dotted line represents response to the negative control, a 3.24 s noise stimulus (n = 180). Numbers above bars indicate sample sizes (this 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.

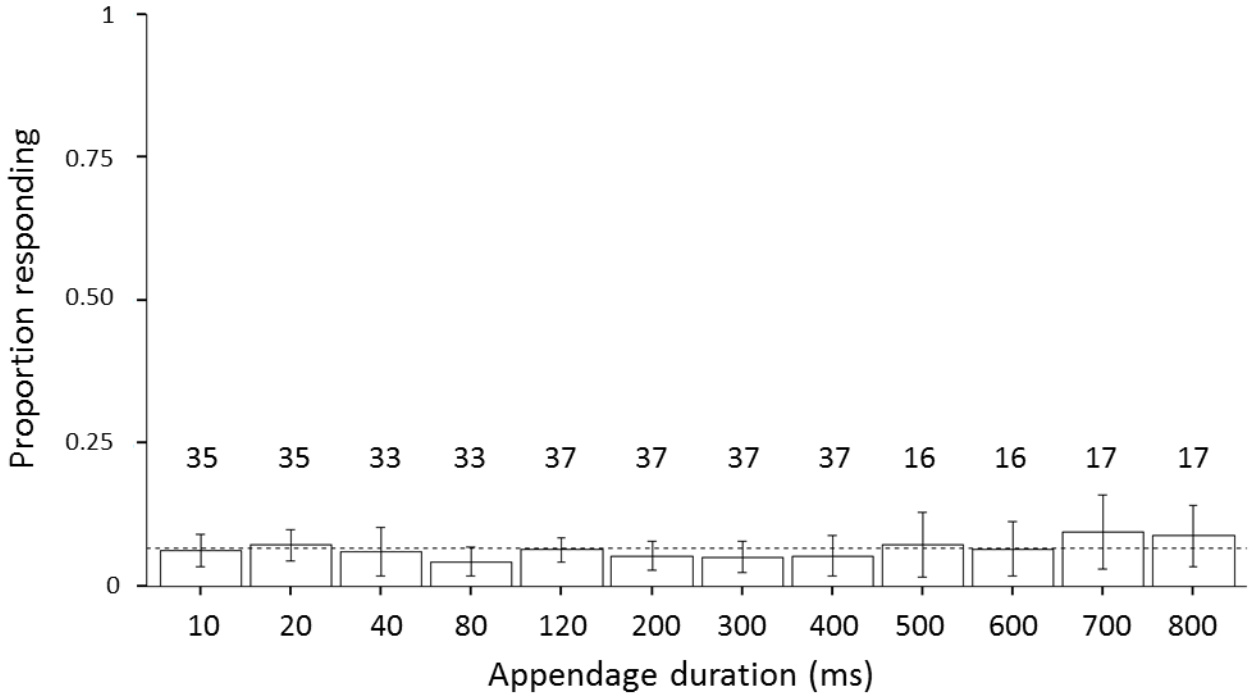


Figure S9: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 8 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.

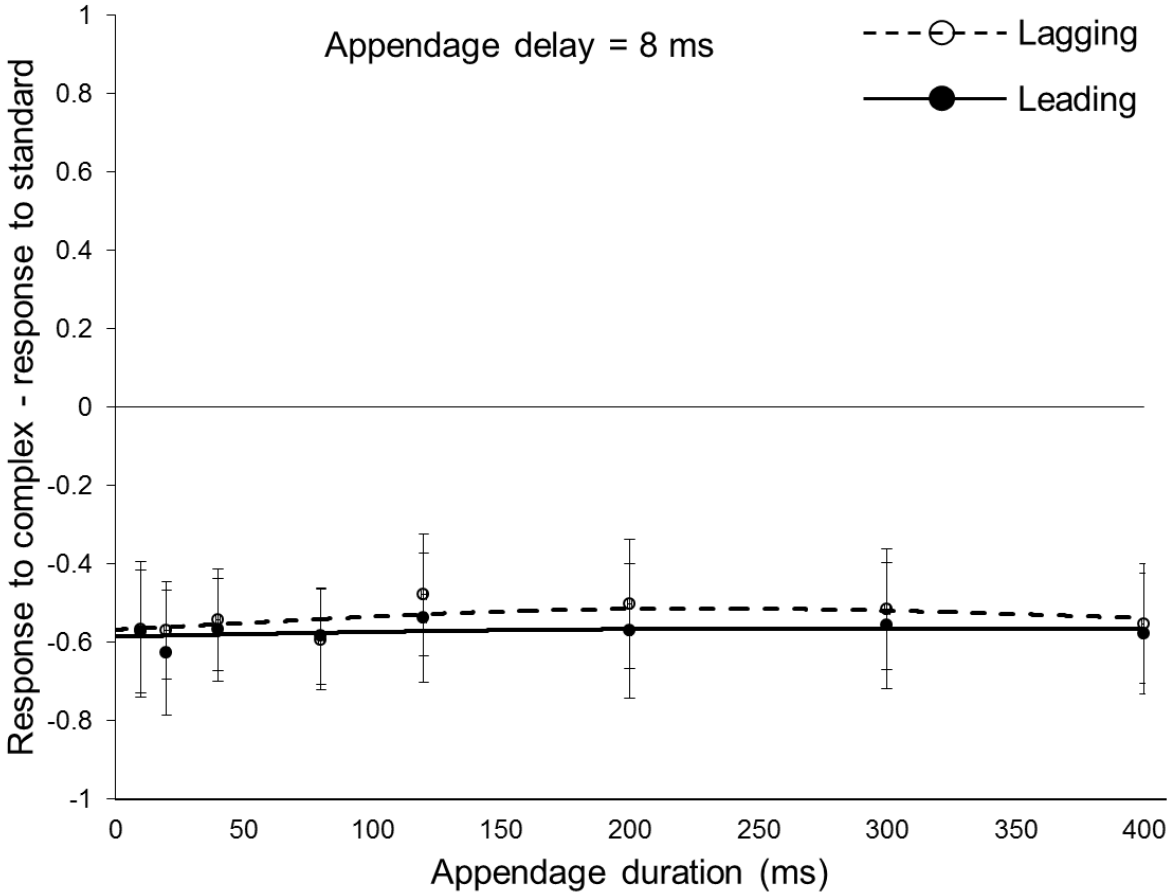


Figure S10: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 32 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.

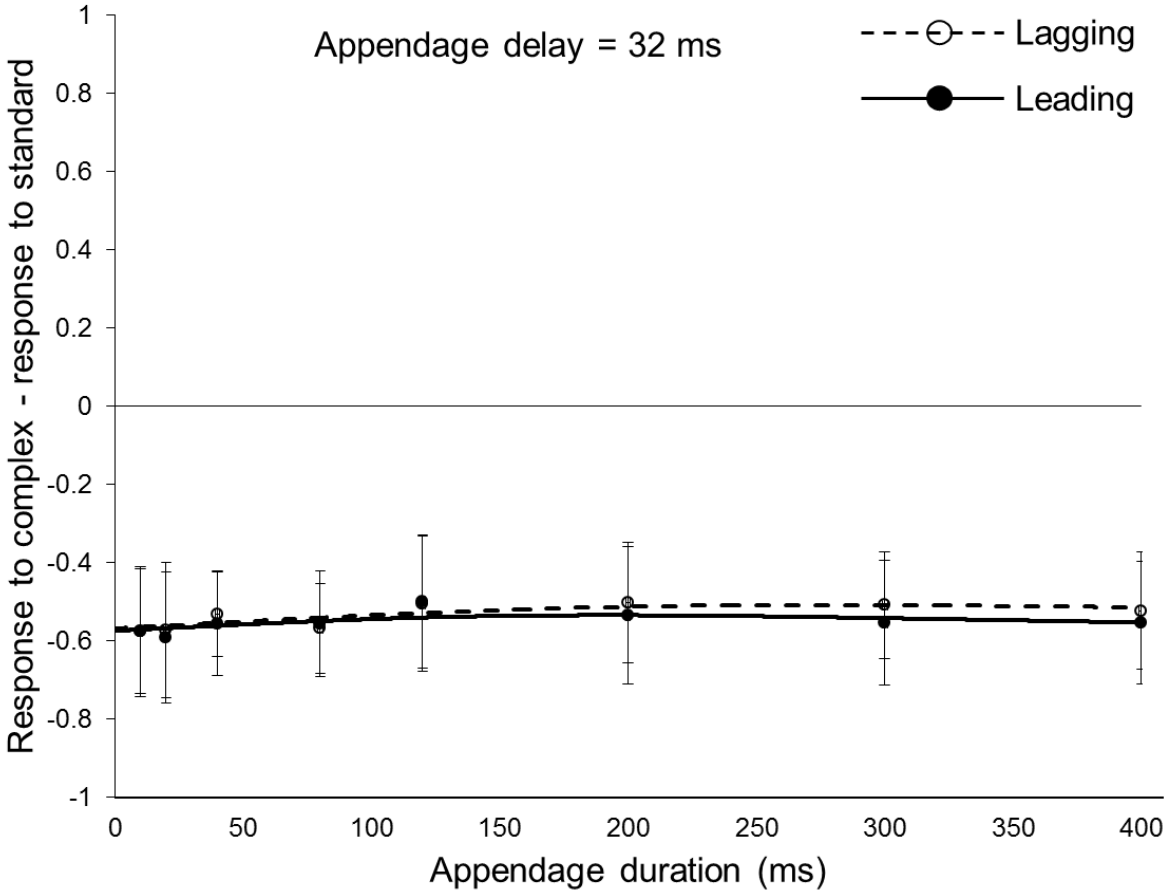


Figure S11: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 64 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.

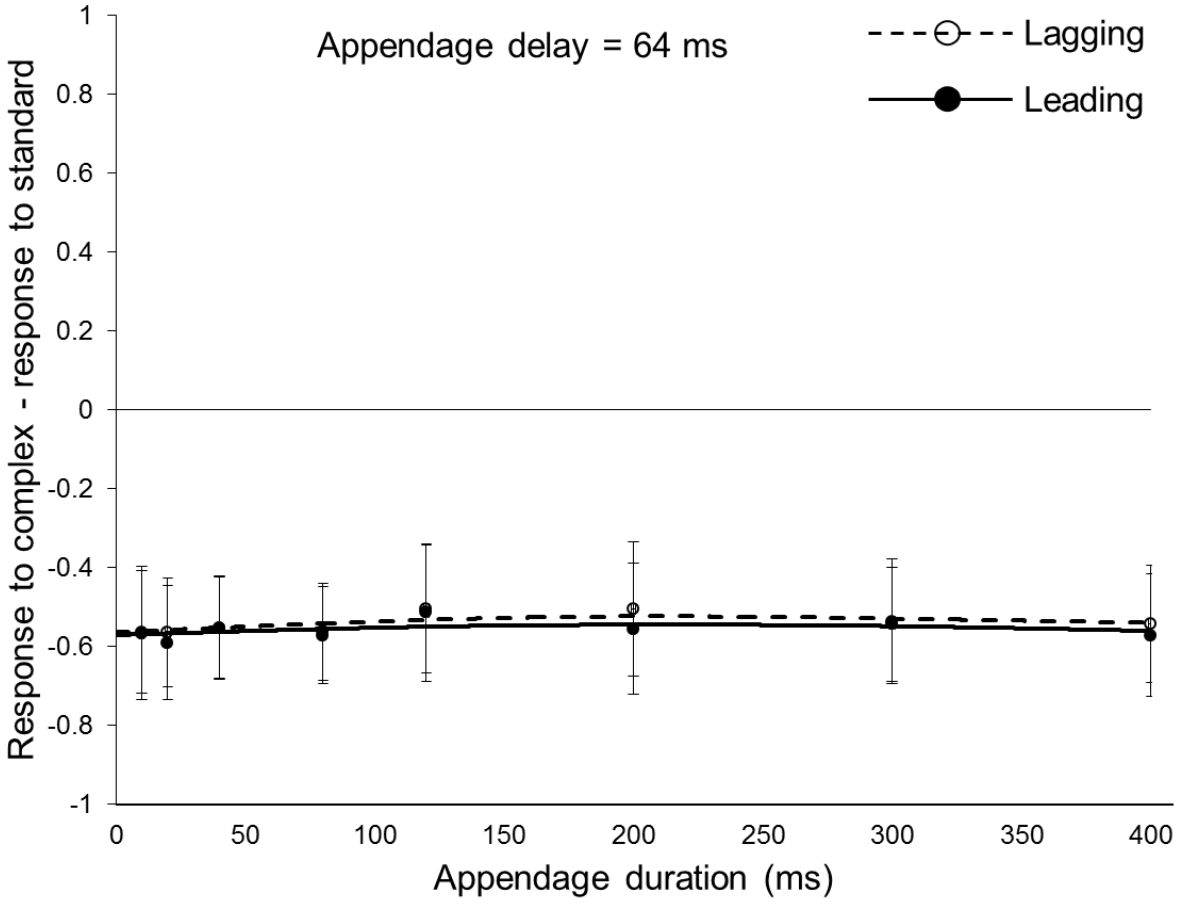


Figure S12: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 100 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.

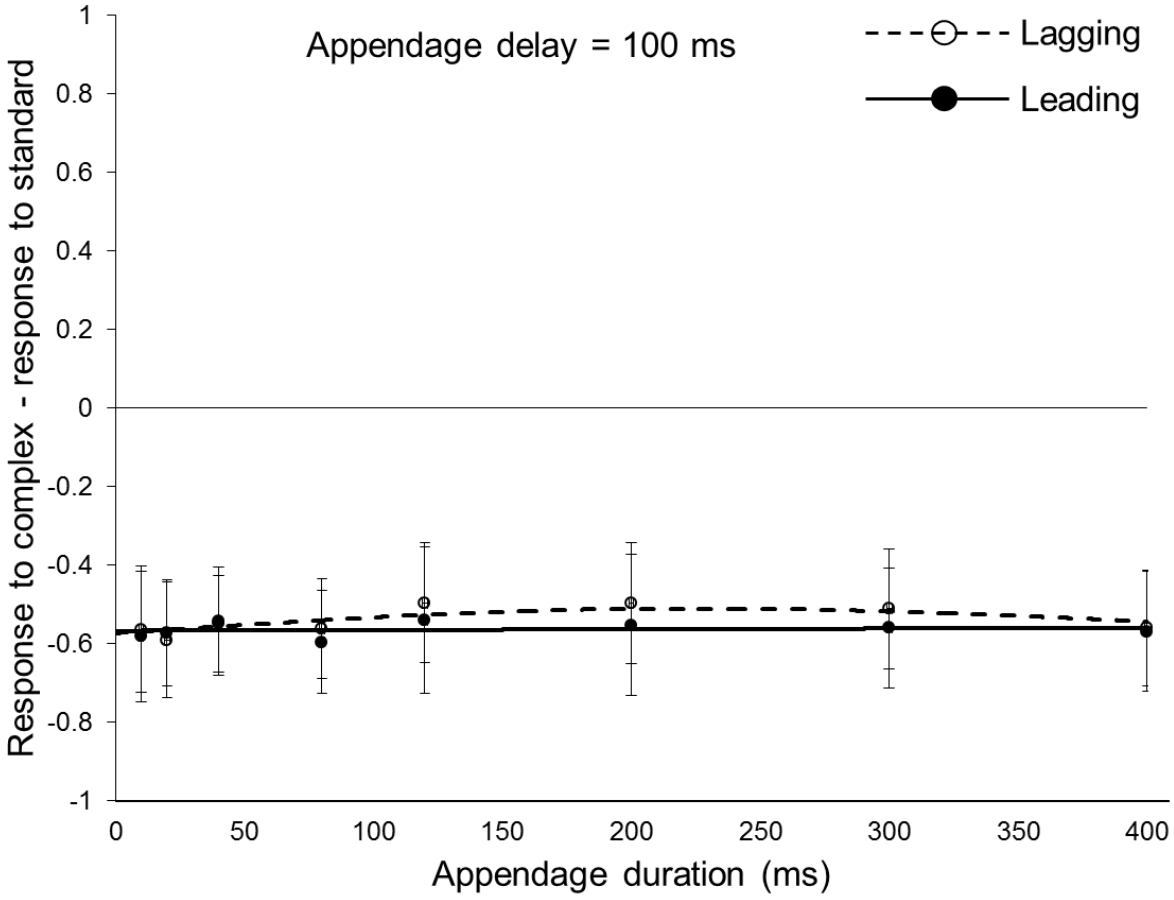


Figure S13: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 200 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.

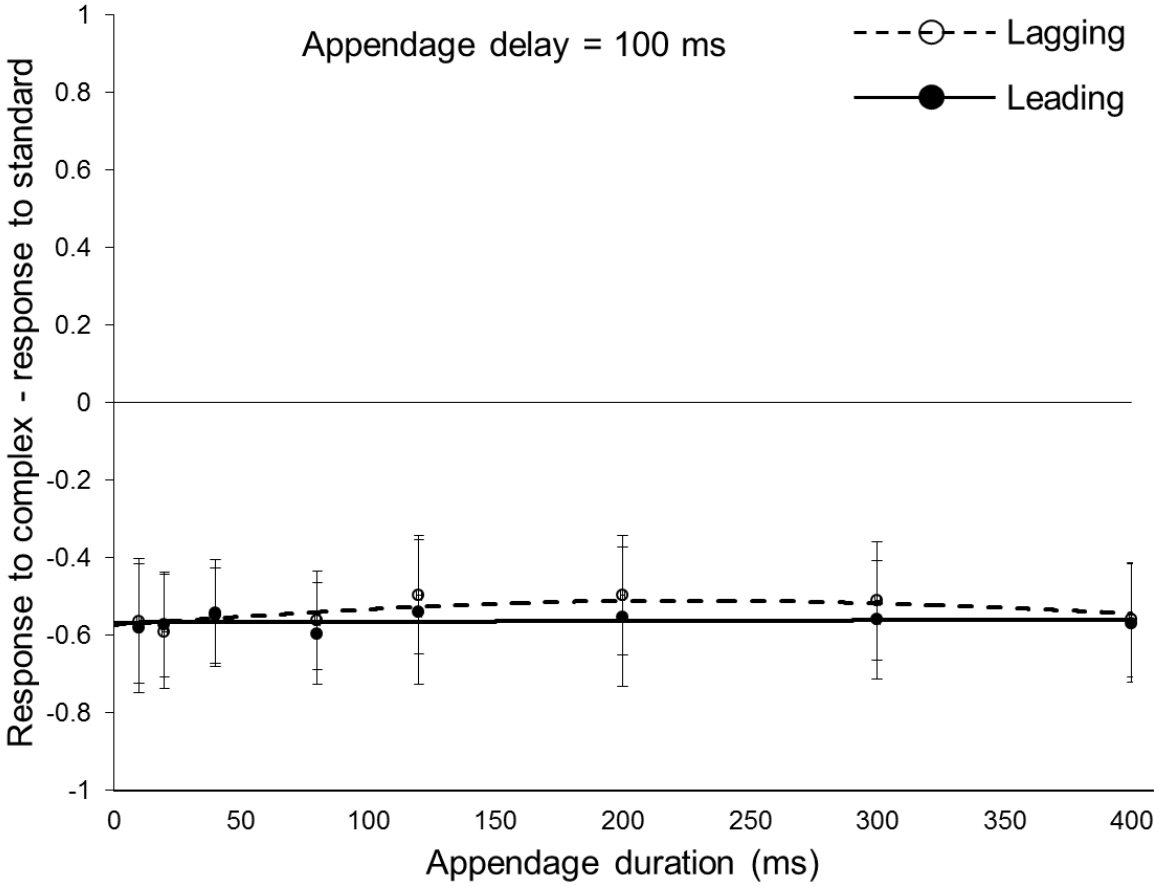


Figure S14: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 300 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.

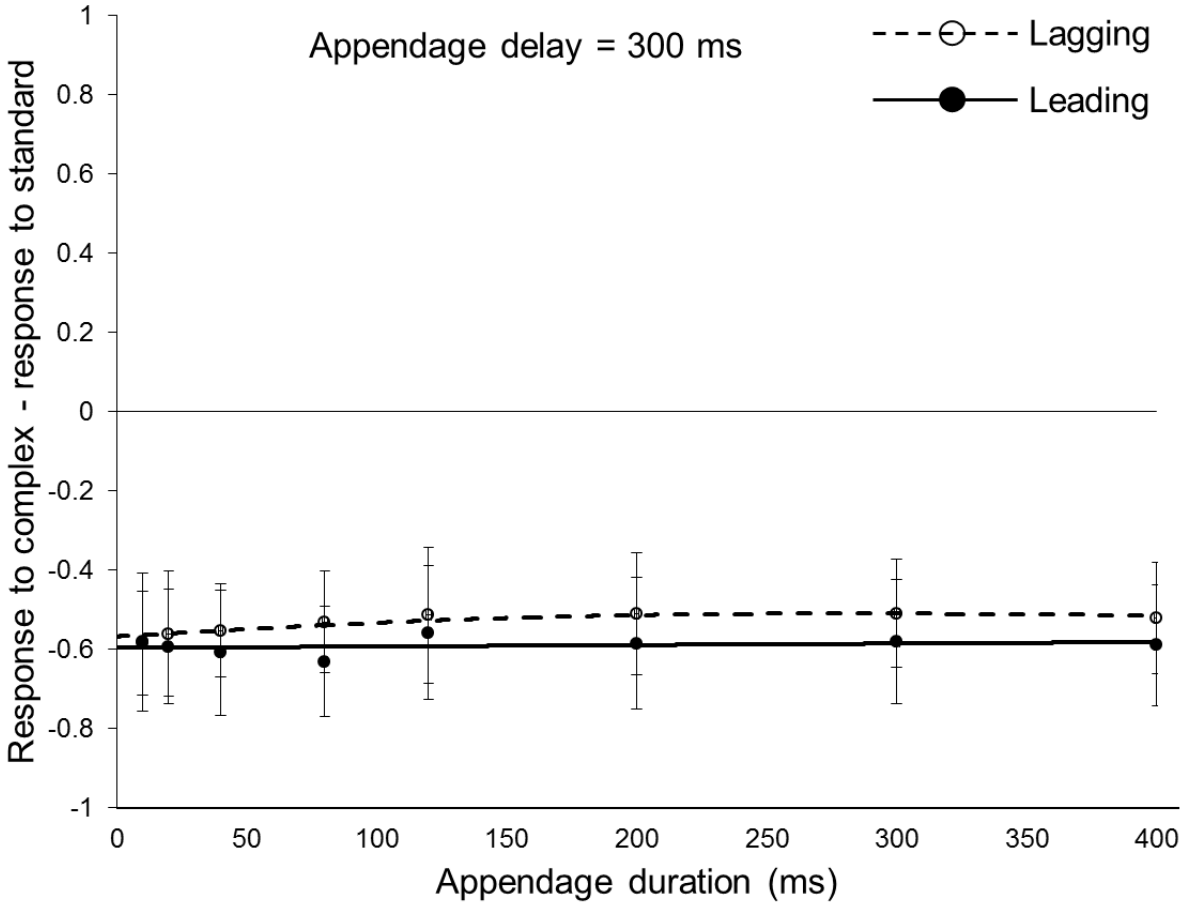


Figure S15: Responses of females in Experiment 3 to complex songs with noise appendages of varying duration, appended to the gappy song stimulus with a delay of 400 ms. Interpretation as in Figure S1. Sample sizes are given in Table S1.

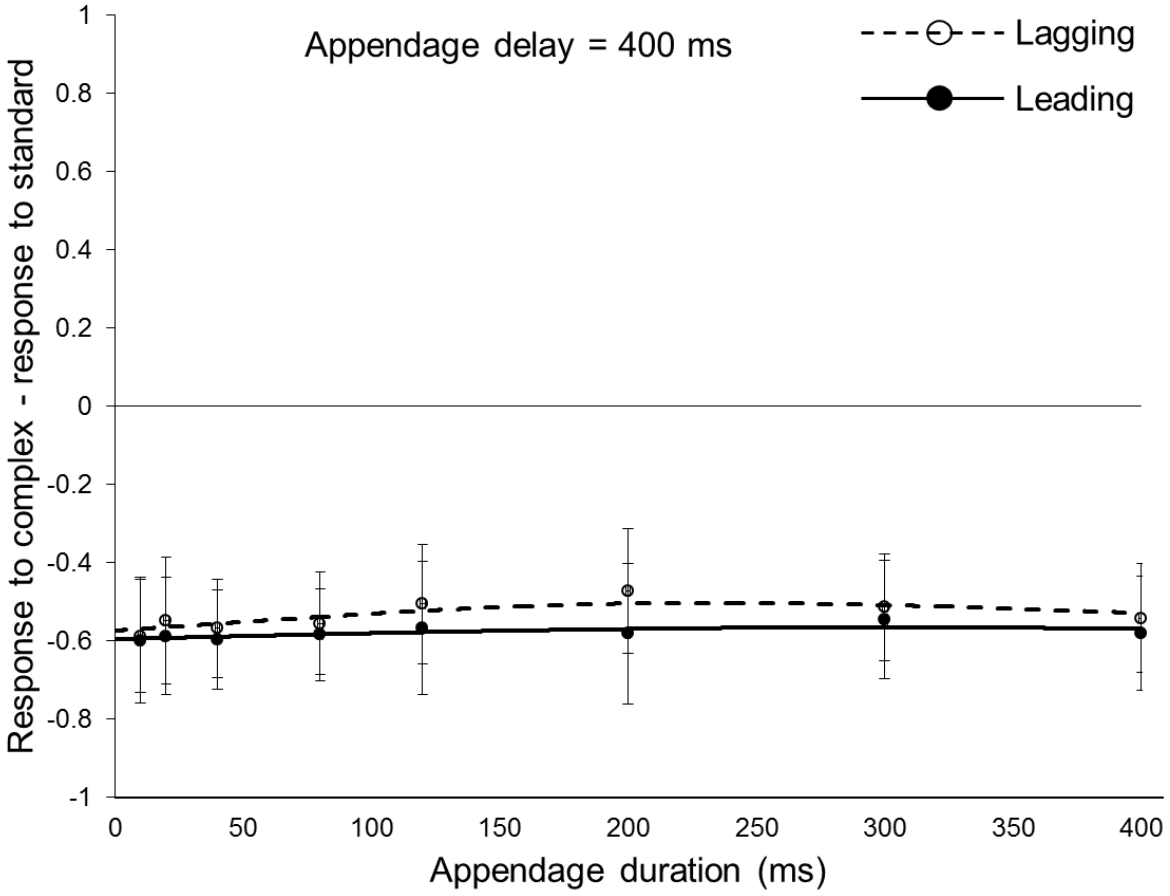


Figure S16: Responses of females in Experiment 4 to the heterospecific appendage stimuli. For these stimuli, the appendage was presented in isolation, without any base calling song. Dotted line represents the average response to the negative control, a 3.24 s noise stimulus (n = 63). Numbers above bars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

