Supplemental Information

Birds Learn Socially to Recognize Heterospecific

Alarm Calls by Acoustic Association

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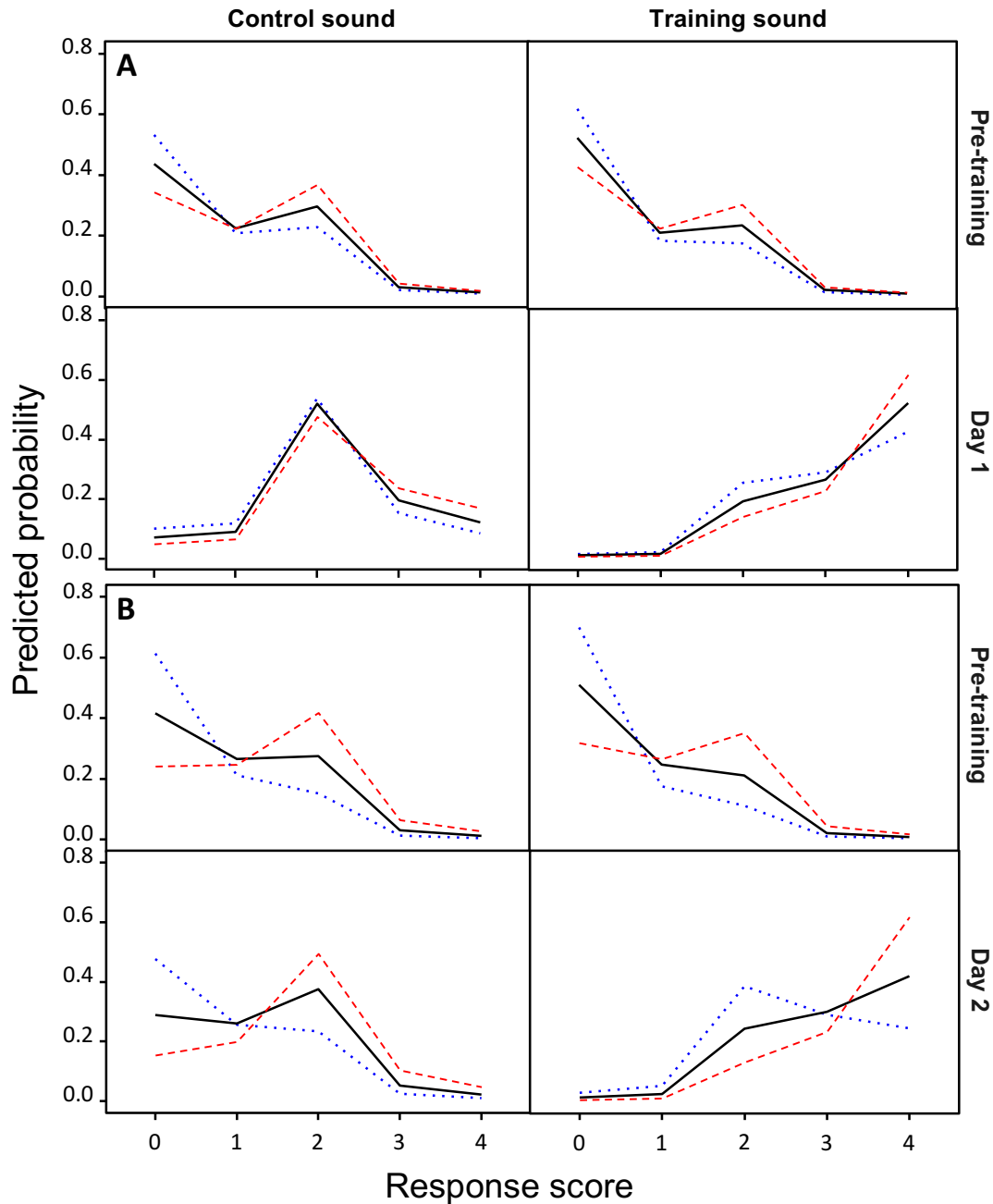
Figure S1. Model predictions of response to playbacks of unfamiliar sounds before versus after training. Related to Table S1 and Figure 3 (A-C).
Unfamiliar sounds were classified as control sounds if they were not broadcast during the training stage, or as training sounds if they were broadcast during training playbacks at the same time as choruses of known aerial alarm calls. The y-axis shows the predicted probabilities of response from the final CLMM model for an average bird (solid black line), a very unresponsive bird (5th percentile for overall responsiveness, dotted blue line) and a highly responsive bird (95th percentile for overall responsiveness, dashed red line). (**A**) Responses before training compared to Day 1 (30 min to 24 h after the last training playback), and (**B**) before training compared to Day 2 (the day following Day 1). Responses of focal birds were scored as a ranked variable: 0, no response; 1, glance, look for < 1 s; 2, scan, look for ≥ 1 s; 3, glance or scan then flee to cover; or 4, immediately flee to cover. The final model for both Day 1 and Day 2 showed that the response was affected by the interaction between sound role (whether it was a control or training sound) and stage (before versus after training) (**Table S1**).
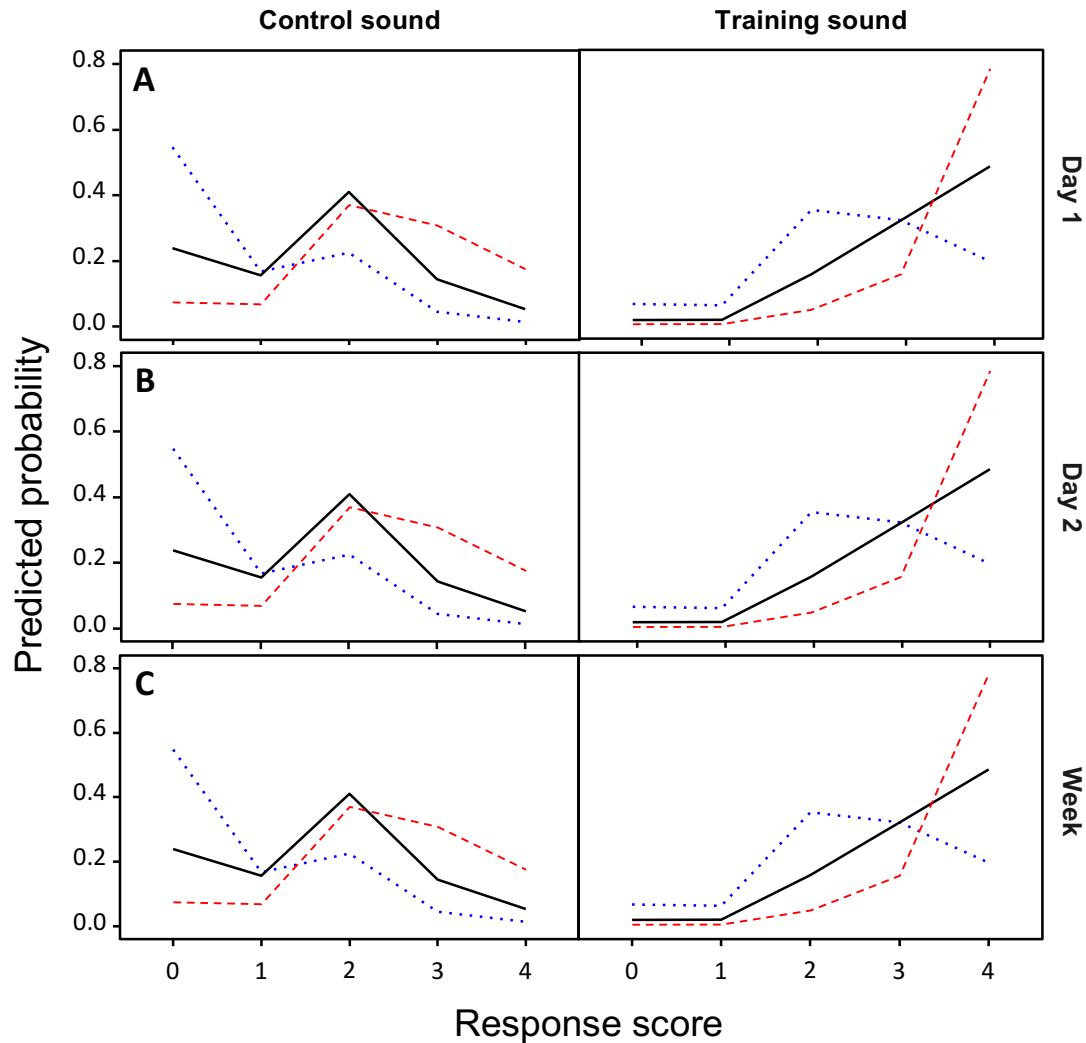
Figure S2. Model predictions of response to playbacks of unfamiliar sounds during the week following training. Related to Table S2 and Figure 3 (B-D).
Unfamiliar sounds were classified as control sounds if they were not broadcast during the training stage, and as training sounds if they were broadcast during training playbacks at the same time as choruses of known aerial alarm calls. The y-axis shows the predicted probabilities of response from the final CLMM model for an average bird (solid black line), a very unresponsive bird (5th percentile for overall responsiveness, dotted blue line) and a highly responsive bird (95th percentile for overall responsiveness, dashed red line). (**A**) Responses on Day 1 (30 min to 24 h after the last training playback), (**B**) Day 2 (the next day), and (**C**) Week (about 7 days after training finished). Responses of focal birds were scored as a ranked variable: 0, no response; 1, glance, look for < 1 s; 2, scan, look for ≥ 1 s; 3, glance or scan then flee to cover; or 4, immediately flee to cover. The final model showed that the response was affected only by sound role (whether it was a control or training sound), and not by the day on which the playback was done, or the interaction of role and day (**Table S2**). The predictions for each day are therefore identical.
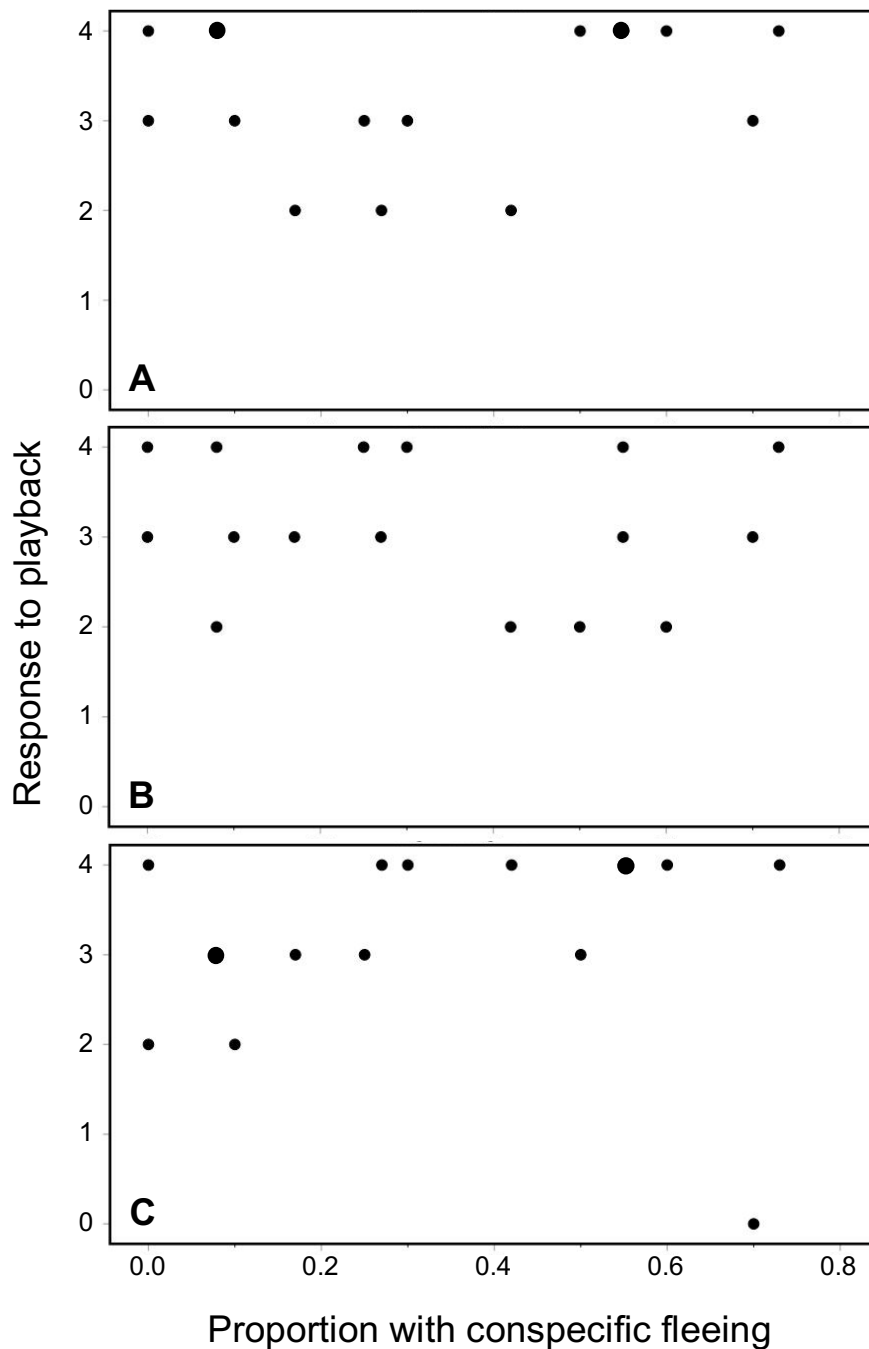
Figure S3. Response of individuals to training sounds after training according to the behavior of nearby conspecifics during training. Related to Results main text analysis and Figure 3.
The x-axis shows the proportion of trials in which a conspecific within 10 m fled to cover during the training alarm-chorus playbacks. The y-axis shows the ranked response of focal birds to playback of training sounds at (**A**) Day 1 (30 min to 24 h after the last training playback); (**B**) Day 2 (the following day); (**C**) Week (about 7 days after training finished). Responses of focal birds were scored as a ranked variable: 0, no response; 1, glance, look for < 1 s; 2, scan, look for ≥ 1 s; 3, glance or scan then flee to cover; or 4, immediately flee to cover. Spearman rank correlations revealed no significant relationship between conspecific fleeing and response on any day (see main text). N = 16 individuals; larger symbols in **A** and **C** represent two overlapping points.

	Fixed effect	LRT	df	*P*
Day 1 Minimal model: response ~ stage + role + stage*role + (1|bird ID)				
Significant terms	role:stage	5.731	1	0.017
Dropped terms	sex	0.699	1	0.403
	sound type	0.279	1	0.598
	conspecific flee	0.004	1	0.952
Day 2 Minimal model: response ~ stage + role + stage*role + (1|bird ID)				
Significant terms	role:stage	11.76	1	< 0.0001
Dropped terms	sex	0.216	1	0.642
	sound type	0.541	1	0.462
	conspecific flee	0.019	1	0.892

Table S1. Test of learned recognition, using Cumulative Link Mixed Model (CLMM) analyses of individual response to playbacks before training compared to after training. Related to Figure S1 and Figure 3 A–C.

Pre-training was compared separately to Day 1 (above; 30 min to 24 h after the last training playback) and Day 2 (below; the following day) after training. The response was measured as a ranked variable: 0, no response; 1, glance, look for < 1 s; 2, scan, look for ≥ 1 s; 3, glance or scan then flee to cover; or 4, immediately flee to cover. The key prediction of learning was an interaction between stage (before versus after training) and sound role (control versus training sound). The additional fixed terms listed were dropped during backwards model selection, based on likelihood ratio tests (LRT), and then added to the minimal model to get probability values. Dropping single terms from the maximal model produced identical conclusions and similar probability estimates. Sound type was the TB or Buzz unfamiliar sound, and conspecific flee indicates whether a conspecific within 10 m of the focal bird at the time of playback fled to cover or not. The random term was individual bird identity. Model predictions are shown in **Figure S1**.

	Fixed effect	LRT	df	*P*
Minimal model: response ~ role + (1|bird ID)				
Significant terms	role	39.41	1	<0.001
Dropped terms	day	4.200	2	0.122
	role:day	2.034	2	0.362
	sex	0.279	1	0.597
	sound type	0.014	1	0.906
	conspecific flee	0.682	1	0.409

Table S2. Test of the retention of learned recognition, using a Cumulative Link Mixed Model (CLMM) of individual response to playbacks on three days in the week after training. Related to Figure S2 and Figure 3 B–D.
Playbacks were carried out at: Day 1 (30 min to 24 h after the last training playback); Day 2 (the following day); and Week (about 7 days after training finished). The response was measured as a ranked variable: 0, no response; 1, glance, look for < 1 s; 2, scan, look for ≥ 1 s; 3, glance or scan then flee to cover; or 4, immediately flee to cover. The lack of an interaction between day (Day 1, Day 2 or Week) and sound role (control versus training sound) indicates that the strength of the learned response to training sounds did not diminish over the week. The additional fixed terms listed were dropped during backwards model selection, based on likelihood ratio tests (LRT), and then added to the minimal model to get probability estimates. Dropping single terms from the maximal model produced identical conclusions and similar probability estimates. Sound type was the TB or Buzz unfamiliar sound, and conspecific flee indicates whether a conspecific within 10 m of the focal bird at the time of playback fled to cover or not. The random term was individual bird identity. Model predictions are shown in **Figure S2**.