Heterospecific eavesdropping of jays (Garrulus glandarius) on blackbird (Turdus merula) mobbing calls

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Abstract
Heterospecifics eavesdrop on mobbing calls and respond with appropriate behavior, but the functional aspects are less studied. Here, I studied whether jays (Garrulus glandarius) eavesdrop on blackbird (Turdus merula) mobbing calls in comparison to blackbird song. Furthermore, it was studied whether jays provided with extra information about predators differ in their response. Three different experimental designs were carried out: (1) control playback of blackbird song to control for the species’ presence, (2) experimental playback of different mobbing events of blackbirds towards different predators, (3) experimental playback similar to (2) but combined with different predator models. In the combined experiments, mobbing calls were tied to the respective visual stimuli. Comparing the experiments with and without predator presentation, a similar number of jays occurred during the playback-only experiment (n = 7) and the playback combined with model presentation (n = 6). However, during the playback-only experiment, jays approached the speaker closer and stayed for longer time in the nearer surrounding. These results show that jays need extra information to make an informed decision.

Keywords Mobbing · Eavesdropping · Garrulus glandarius · Turdus merula

Introduction
Heterospecific eavesdropping on each other’s alarm or mobbing calls has been found among many bird taxa (Goodale et al. 2010; Magrath et al. 2020), and even in exploitation of food by using deceptive heterospecific alarm calls (Flower et al. 2014). Heterospecific eavesdropping on alarm calls can be beneficial because by warning from shared predators, listeners may benefit from alarm calling of another species. Heterospecific eavesdropping also occurs during mobbing when birds call to alert other con- and heterospecific individuals (Goodale & Kotagama 2008; Hurd 1996). Mobbing is different from alarm calling because mobbers move towards the predator rather than fleeing (Caro 2005). Usually, a perched avian predator is the object of a mobbing event (owl, raptor), but also terrestrial mammalian predators can be targets of mobbing behavior (Caro 2005). While it is well studied that mobbing calls attract heterospecifics which then respond with approach, calling, and wing-flicking (Hurd 1996; Dutour et al. 2017; Randler and Förschler 2011), the functional aspects are less studied.

Curio (1978) presented 10 hypotheses and predictions of avian mobbing. One function is the amalgamation of many species and individuals (alerting others hypothesis) to drive a predator away (move-on hypothesis), but there are only a handful of studies rendering this move-on hypothesis likely (e.g., Pettifor 1990; Pavey and Smyth 1998). However, mobbing calls may also unintentionally alert others, which means that species might not join a mobbing flock but gain information about the mobbing event by eavesdropping. Alerted con- and/or heterospecifics may, however, follow a two-tier process: first be recruited to the area, then decide if it is safe enough to mob and to adjust ones’ behavior, i.e., decide whether and how to participate in mobbing.

In nature, mobbing calls are inevitably linked with a mobbing event being related to the presence of a predator; thus, both visual and acoustic cues and/or signals are available as information for heterospecifics. However, during the last decades, many studies showed that specific calls of mobbing passerines are referential (see, e.g., Suzuki 2012, 2016; Suzuki and Ueda 2013); thus, information is encoded...
in the different calls, and receivers respond adequately when only the calls are presented (Smith 2017). This means that information about the type of the predator and or the danger is included in the mobbing or alarm calls, and receivers respond appropriately towards playbacks of mobbing calls (e.g., Templeton and Greene 2007; Grieser 2009). In some cases, predator category and the risk proposed by the predator are encoded simultaneously (Grieser 2009). However, many studies also showed that responses towards predators are coded via graded signals with a higher rate or duty cycle representing a higher threat (Randler 2012). Concerning mobbing, however, studies are somewhat inconclusive because by playback alone, the reasons for the mobbing event can only be extracted from the calls, but actions carried out by the alarmed heterospecifics are hypothetical because they cannot direct their behavior towards a predator. Nevertheless, previous studies showed clear incidences of intended mobbing behavior, such as wing-flicking and approach (Dutour et al. 2017; Randler and Vollmer 2013).

Here, Eurasian jays (Garrulus glandarius) and blackbirds (Turdus merula) were studied. Blackbirds give loud mobbing calls towards many predators, and these calls also alert heterospecifics (Frankenberg 1981). Jays are larger and heavier but are also predated upon by the same predators and share the same breeding season and habitats. Furthermore, jays participate in mobbing predators (methods). The main question was whether jays that eavesdrop on blackbird mobbing calls do so because they join mobbing activities or whether they extract information from the mobbing calls for their own benefits. Two hypotheses have been addressed in this context.

Hypothesis 1: Jay respond to eavesdrop on blackbird mobbing calls. They should respond stronger towards mobbing calls compared to song playback of the blackbird (alerting others hypothesis).

Hypothesis 2: Predator information; jays eavesdrop and receive information about a predator. The experiment with the model presentation contains more information; thus, the inspecting jay can acquire information faster and the decisions should be quicker. Therefore, jays might not approach as close as in the call-only experiment. Also, visit should be shorter because the model and playback combination contains more information.

Materials and methods

Species

The blackbird (weight: 80–90 g) breeding population in the local region of Tübingen is rather high with 330–370 breeding pairs on a 623-ha study plot (Gottschalk and Randler 2019). Blackbirds breed from March to July and the median date of egg-laying is 24th April, the median date of hatching is 11th May (Hölzinger 1999). During the study in spring, blackbirds were still singing up to then end of June, with high densities of about 2–3 males simultaneously heard from one place. For Jays (weight 160–170 g), the breeding population consists of 35–45 jay pairs on a 623-ha study plot (Gottschalk and Randler 2019). The median of egg-laying is 28th and of hatching 21st (Hölzinger 1997). Thus, there is a considerably overlap of the breeding period making both species susceptible towards predation during the same time frame. Predators of jay and blackbird, e.g., owls and sparrowhawks, are breeding in the area (Gottschalk and Randler 2019, Randler unpubl.). Feral cats were also present in the woods (see Randler et al. 2019) and jays are known to respond to cats as predators (Keve 1995). Data from previous work (Kalb et al. 2019) showed that jays approached during presentation of predators in a study of great tits Parus major.

Field work

Observations were made from 27th May to 26th June 2020, from 6:30 am to 5:00 pm during good weather conditions (no strong wind, no rain). Study locations were near Tübingen (48° 31′ N, 9° 3′ E) and Rottenburg am Neckar (48° 28′ N, 8° 56′ E) in southwest Germany (see Kalb and Randler 2019). Distances between playback sites were on average 2116 ± 1452 m (median 1690; range 404 to 6930 m). A total of 30 different sites have been used. Each site was used only once to avoid pseudo-replication. Playback locations were chosen because jays have been observed during the breeding season in 2019, which was checked again from mid-May onwards in 2020. In cases where the distances between study sites were low (e.g., 404 m), playback locations were chosen because territories were known from regular surveys (e.g., Randler 2020 unpubl.). At every location, blackbirds were breeding in the vicinity.

Playback stimuli

Audio recordings for the playbacks were obtained during the breeding season from different blackbird individuals and from different sites than the playback sites in this experiment (live predators and one stuffed predator presented to adults; for details, see ESM 1). Recordings were slightly edited to erase disturbing background noise and other bird species with Audacity (v2.3.3). Playbacks were made during the breeding season (May–June 2020), thus having an overlapping time frame addressing possible seasonal effects. Playbacks were broadcast using a portable Bluetooth loudspeaker Ultimate Ears Boom 2 (Ultimate Ears, Irvine/Newark) and an mp3 player AGPTEK A26 (AGPTEK). All stimuli were standardized on ten minutes (playback time = observation time). The speaker playback...
output was set to ~80 dB SPL measured in the lab at one meter from the speaker using a PeakTech 8005 sound level meter (PeakTech Prüf- und Messtechnik GmbH, Gerstenstieg 4, 22.926 Ahrensburg, Germany; see Kalb and Randler 2019). This is adequate and presents a natural sound because mobbing blackbirds make a loud noise. After the setup of the experiment, the observer retreated to about ≈50 m.

Three different experimental designs were carried out: (1) control playback of blackbird song to control for the species’ presence (N = 10 different blackbird songs (ESM 1)); (2) experimental playback of N = 5 different mobbing sequences of blackbirds towards different predators, each used two times (ESM 1; total N = 10); (3) experimental playback similar to 2 but combined with 5 different predator models (feral cat Felis catus, tawny owl Strix aluco, long-eared owl Asio otus, magpie Pica pica, little owl Athene noctua; total N = 10). In the combined experiments, mobbing calls were tied to the respective visual stimuli; i.e., mobbing calls towards a cat were presented with a stuffed model of a cat; similarly, it was for tawny owl, long-eared owl, and magpie. Only one playback was obtained towards a human. This was combined with a model of a little owl. The loudspeaker was placed about two meters away from the model. In sum, thirty different playbacks at thirty different locations were carried out (independent samples). The data were pooled across all predator types to examine a general mobbing response to predators (captured by using a variety of predators) as opposed to focusing on one or two species or types of predators (compare with Randler 2007).

**Outcome variables**

The following variables were collected during the playback trials: whether a jay approached the speaker (dichotomous), latency time until the first response (approach or call), time spent within a radius of 5 m around the speaker, and minimum distance to the model/loudspeaker (direct, in m). The radius of 25 m was chosen haphazardly because previous studies using mounts during winter showed that jays did not always approach to such close distances like parids. Obvious mobbing behavior, such as diving towards the model or attacking, was also in the focus but did not occur. To measure time, a stopwatch was used. Distances between the model/loudspeaker were measured by a ruler and by a Nikon Aculon distance meter. The Nikon Aculon measures distances from 5 to 1000 m. To observe the birds, a Swarowski EL 10×50 was used. Behavior was videotaped with a Nikon D7100 and an 80–400 mm Zoom Nikkor lens (Nikon GmbH Düsseldorf, Germany).

**Statistical analyses**

For comparing categories, a chi-square test was used and for comparison of minimum distance and time spent within the 25 m radius; as the data was not normally distributed, non-parametric Mann–Whitney U tests were performed using SPSS 26 (IBM, Co., Armonk, NY).

**Results**

During ten blackbird song playbacks, no jay occurred, while in seven out of ten mobbing playbacks, jays approached the speaker ($\chi^2 = 10.769, df = 1, p = 0.001$). Time spent within a 25 m radius near the playback speaker differed significantly with 0 s in the song experiment and 31.8 s in the mobbing playbacks (Mann–Whitney U test, Z = −3.104, p = 0.002).

During the playbacks combined with a model presentation, in 6 out of 10 cases, jay occurred. This was not significantly different from the playback-only procedure ($\chi^2 = 0.220, df = 1, p = 0.639$, Fig. 1).

Thus, a similar number of cases occurred during the playback-only experiment and the combination of playback with model presentation. The latency until the first response did not differ between the playback-only and model presentation (Z = 2.939, p = 0.086). However, during the playback-only experiment, jays approached the speaker closer (7.5 vs. 73; Z = −2.718, p = 0.007; Fig. 2) and stayed for longer time in the nearer surrounding (within 25 m; 31.8 versus 9.5 s; Z = −1.986, p = 0.047).

No strong, obvious mobbing behavior such as attacking or diving flights towards the predator occurred.

**Discussion**

First, I found that jays did not respond to the blackbird songs, but to mobbing calls, which confirms hypothesis 1 and suggests that jays eavesdrop on the signal of a blackbird directed towards a predator, but not towards the presence of the blackbird itself when the predation context is lacking (similar to Forsman and Mönkkönen 2001 for other species). Thus, this study adds to previous studies demonstrating heterospecific eavesdropping in a mobbing context (Goodale et al. 2010; Magrath et al. 2020). The data of mobbing playbacks was pooled across different predators to generalize across different predator threats (comparable to Randler 2007). Further studies now should assess responses of jays towards different predators of blackbirds. Some of these predators may preferably predate on nest and young (e.g., magpie), others on adults, and some on both (cats). However, the detailed response towards different blackbird playbacks was not in the focus of the study.
The study further suggests that jays have incomplete information about the reason of the blackbird mobbing in the playback-only experiment, because they approached closer and stayed longer in the playback-only experiment as the exact position or identity of the predator is unknown. When the respective reason of the mobbing activity is presented by including a model predator, jays approached less close and stayed shorter, because the information about the predator and its location is complete, confirming hypothesis 2. Thus, the study shows that jays need extra information to make an informed decision about their response towards the mobbing calls of blackbirds. Comparably, in yellowhammers Emberiza citrinella, individuals with less complete information about a predator exhibited alert perching more often immediately after the encounter than did birds that saw a predator model (van der Veen 2002). Generally, obtaining information by directly observing a situation is more reliable than indirect information obtained from the behavioral decisions of other individuals (Giraldeau et al. 2002; Barrera et al. 2011; Magrath et al. 2009).

Many animals use heterospecific calls to gain information about the current predation risk, but not always in a
reciprocal manner. In some cases, this is considered as information exploitation. Such exploitation has been documented, e.g., in Downy Woodpeckers, Picoides pubescens (Sullivan 1984), where woodpeckers reduced their vigilance when playbacks of heterospecific contact calls have been broadcast. The heterospecific contact calls were perceived as a cue of safety. Furthermore, downy woodpeckers did not respond to predator presentations with alarm calling (only in cases when a conspecific of the opposite sex was present), while tufted titmice, Baeolophus bicolor, and black-capped chickadees, Poecile atricapillus, often gave alarm calls in predator contexts. Thus, the downy woodpeckers exploited the information provided by the smaller songbirds but did not “pay back” by own alarm calling (Sullivan 1985). Playback experiments with Western Australian magpies (Cracticus tibicen dorsalis), for example, showed that magpies take into account the reliability of a caller (Silvestri et al. 2019). Magpies were exposed to alarm calls of two group members: one was played in the presence of a predator model while the other was not. In a second trial, playbacks of the group members were presented without a predator model and the receiver responded stronger to signallers that previously gave alarm calls in the presence of a predator model. Nuthatches, Sitta europaea, alter the acoustic features according to whether they gained direct or indirect information about a threat. When receiving direct information, they produced mobbing calls reflecting the given threat. However, when obtaining indirect information, they only produce calls with intermediate acoustic features, suggesting that this species is sensitive to the source and reliability of information (Carlson et al. 2020). The behavior of jays when hearing blackbird mobbing calls can also be explained by information exploitation, but the data are only suggestive about that and need further scrutinization. To test for exploitation, it is important to see if the receivers help the signaler (i.e., by mobbing) or not (exploitation). This needs to be tested explicitly with analyses of mobbing behavior including wing flicking, tail flicking, and other mobbing behaviors. In this study, only obvious mobbing behavior was studied (attack flights, diving towards the model), but such behavior did not occur, and future studies should focus on these more subtle behaviors. Also, when presenting only blackbird mobbing calls, jays—even when they wanted to participate in mobbing—have no target for an attack because attacking the speaker would mean attacking the blackbird, not the predator. An interesting additional experiment would be to present jays with the model predators only.

Alternatively, jays might also use mobbing calls of blackbirds during the breeding season to eavesdrop to locate a blackbird’s nest to prey upon the eggs or young. Future studies might investigate this possibility by testing if jays search for a blackbird’s nest after hearing mobbing calls if no model predator is present. Then, jays should not mob, but rather approach carefully to search for the nest. In this case, however, jays should stay longer within the area to try to locate the nest, and artificial nests of blackbirds should be preyed upon by jays more often when blackbird mobbing calls are played back. In turn, the reaction of the blackbirds would be interesting, because the blackbirds may be aggressive to the jays if they did approach even if they would help mobbing. In this case, one would expect seasonal differences in mobbing, with fewer approaches of jays during the breeding season and more during winter.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s10211-022-00391-4.

Funding Open Access funding enabled and organized by Projekt DEAL. This study was supported by the Gips Schüle Stiftung, Stuttgart (Professur Fachdidaktik Biologie, #27386).

Data availability Data are available via the Open Science Framework osf.io/ftzma.

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