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BRIEF COMMUNICATION

Heart Rate Responses to Induced Challenge Situations in Greylag Geese (*Anser anser*)

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Adequate short-term responses to stressors are of great importance for the health and well-being of individuals and factors modulating the physiological stress response (e.g., controllability, suddenness, familiarity) of a stimulus are well described under laboratory conditions. In the present study we aimed at investigating the stress response in greylag geese (*Anser anser*) in the field, confronting individuals with naturally occurring stressors. We measured beat-to-beat heart rate (HR) via fully implanted transmitters during three different experimental challenges: (1) catching and holding, (2) confrontation with a model predator, and (3) approach by different humans. We compared this to a control period and HR during agonistic encounters, a naturally occurring stressor. All three experimental situations evoked a HR increase. Highest HR responses were elicited by catching and holding the animals. In the third experiment, HR responses were greatest when the geese were approached by a human stranger (i.e., somebody the geese have never seen before). Hence, geese discriminated between different kinds of stressors and adjusted their physiological response depending on the type of stressor. Our results show that geese were able to discriminate between individual humans. In line with a number of lab studies, we suggest that particularly the controllability of certain situation determines the intensity of the HR response, also in a natural setting in the field.

Keywords: Anser anser, catching and holding, greylag geese, human approach, model predator

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Greylag geese, as all other animals including humans have to cope regularly with a variety of stressors (e.g., environmental: Frigerio, Dittami, Möstl, & Kotrschal, 2004, social: Wascher, Arnold, & Kotrschal, 2008). A considerable body of literature deals with physiological responses to different stressors in various animal species (e.g., **handling**: lizards, *Iguana iguana* and frogs, *Rana catesbeiana* and *Rana pipiens*: Cabanac & Cabanac, 2000; chicken, *Gallus domesticus:* Cabanac & Aizawa, 2000 or common eiders, *Somateria mollisima:* Cabanac & Guillemette, 2001; **human approach**: oystercatcher, *Hematopus ostralegus:* Hüppop & Hagen, 1990; frigate birds, *Fregata magnificens,* blue-footed boobies, *Sula nebouxii,* waved albatrosses*, Phoebastria irrorata* and swallow-tailed gulls, *Creagrus furcatus*: Jungius & Hirsch, 1979; **predator approach**: bighorn sheep, *Ovis Canadensis*: MacArthur, Johnston, & Geist, 1979). All these studies investigated the impact of a single stressor onto an individual's physiology, whereas responses to different types of stressors are rarely compared in the same study. Dogs (*Canis lupus familiaris*) have been confronted with six different stressors and behavioral, cortisol as well as heart rate responses have been measured but could not be correlated (Beerda, Schilder, van Hooff, de Vries, & Mol, 1998). In a more systematic study, Nephew and colleagues (2003) investigated the effects of five different stressors (auditory, visual, antagonistic, novel human, caretaker) onto behavior, HR and corticosterone levels. The results of this study suggest, that the stress response is regulated depending on the stressor but the three pathways (behavior, corticosterone, HR) are modulated independently.

In the present study, we aimed to investigate, how different stressors would affect HR in free-living greylag geese in an intact social environment. Therefore, we compared HR during three different challenges (catching and holding, approach by a model predator, and different humans) and HR during agonistic encounters, a naturally occurring stressor. We expect HR to increase stronger during less controllable situations (e.g., handling) than during more controllable situations (e.g., human approach).

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Methods

The Flock

A nonmigratory, free-roaming flock of greylag geese was introduced in the Almtal (Upper Austria) by late Konrad Lorenz in 1973. At the time of the study the flock consisted of approximately 150 individuals, marked with colored leg bands for identification. Geese are habituated to the close presence of humans and do not show avoidance if approached up to 1 m distance, nor do they excrete elevated levels of corticosterone metabolites following such situations (Scheiber, Kralj, & Kotrschal, 2005).

Transmitter Technology and Implantation Technique

Twenty-four focal individuals were fitted with a fully implanted sensor-transmitter package without external antennas or repeater, weighing approximately 60*g* with a battery lifetime of 18 months. The HR was transmitted instantaneously on a beat to beat basis over distances up to 100 m (Prinzinger et al., 2002). The transmitter was calibrated to record in the range of 30 to over 500 beats per minute. The electronic package was implanted by an experienced team of veterinarians into the abdominal cavity (unpublished data; license number GZ68.210/41-BrGT/2003 by the Austrian government). For details of the implantation see also Wascher, Scheiber, Weiß, & Kotrschal (2009).

Data Collection

Experiment 1: Catching and Holding

In the course of two time periods, October/ November 2005 and August, 2006, experimental catching and holding has been conducted in 14 individuals (seven males, seven females; 12 paired, two unpaired). HR in this experiment has been recorded by CW. The focal individual was caught by hand (picked up, without a chase) and held for 1 minute. Afterward, animals were released into the flock and their HR was recorded continuously for 5 minutes thereafter.

Experiment 2: Confrontation With a Model Predator

From August to October 2006, 11 individuals (seven males, four females; nine paired, two unpaired) were approached by a leashed dog, guided by a human (A.B.), who approached the focal individual in fast walking speed until it was just about to take off. In all cases, the dog approached the geese closer than 5 m, but never closer than 1m. Our geese are not habituated to the presence of dogs. HR in this experiment was recorded by CW. After a 3-minute control period, the human guiding the dog approached the focal goose without the dog before and after the experiment, to see which kind of HR response the human approach elicited without the dog.

Experiment 3: Human Approach

The experiment was conducted from January- March 2007 in seven male greylag geese (five paired, two unpaired). HR was recorded by S. Woche. All geese were approached twice (morning and afternoon) by 12 different humans, in randomized order. Three of them were familiar to the geese, which means at the time of data taking, these persons were working in close contact with the geese (i.e., by taking data, feeding) for at least 2 years. Six people were known to them, because they passed by the geese every once in a while, but did not work with them. Three people were complete strangers, who were never seen by the focal geese before. At the beginning of the experiment, the focal goose rested without any human being closer than 3 m, then a human started to approach it slowly. We differentiated between 4 different distance categories during the approach: A->3–2 m; B-2–1 m; C-1–0.5 m; D-0.5–0 m. The human approached until the focal individual showed avoidance behavior (e.g., getting up and walking away). This happened within distance category D in all cases.

Control Periods and Social Stressors

Before and after each experiment, we recorded HR for one (Experiment 1) respectively three minutes (Experiment 2 and 3). Mean and maximum HRs are used as control period. In the course of another study we recorded HR of the 24 focal individuals during 1602 agonistic encounters (Wascher et al., 2009). Here, we used mean and maximum HRs from our focal individuals during all occurring agonistic interactions.

Statistical Analysis

Data were analyzed using the Sigma Stat statistical package (Systat Software, 2006). Results of all tests are given two-tailed and significance was set to $p = .05$. As data deviated in part from a normal distribution, we applied nonparametrical Wilcoxon signed-ranks test to compare HR variation between different conditions. The p values are based on T^+ if sample size was $N \leq 15$, and on z if $N > 15$ (Siegel & Castellan, 1998). Friedman's two-ways analysis of variance (ANOVA) by rank was applied to compare HR response in different distance categories during human approach. As focal individuals differed between experiments, we did not compare differences over all situations. Details about statistics are given in supplementary material online.

Results

Maximum HR was significantly higher during the three experimentally induced challenges compared to the maximum HR during control periods and agonistic encounters (Figure 1A). Mean HR was elevated in all three experimental conditions compared to control. Mean HR during agonistic encounters was significantly higher than during human approach, but lower than when caught or approached by a dog (Figure 1B). HR was significantly higher during and the first minutes after being caught and held compared to the control condition before handling (Friedman's analysis of variance by ranks: mean HR: $p = .001$, $df = 3$, $\chi^2 = 34.44$, $p < .001$). HR significantly increased when being approached by a dog (Friedman: mean HR: $p < .001$, $df = 3$, $\chi^2 = 23.76$, $n = 11$) or human (Friedman: mean HR: $p = .001$, $df = 5$, $\chi^2 = 20.288$, $n = 7$, Figure 2). We found a significant difference in mean HR during approach by familiar humans, unfamiliar humans and strangers in the distance category C (1–0.5 m; Friedman: mean HR: $p = .05$, $df = 2$, $\chi^2 = 6$, $n = 7$).

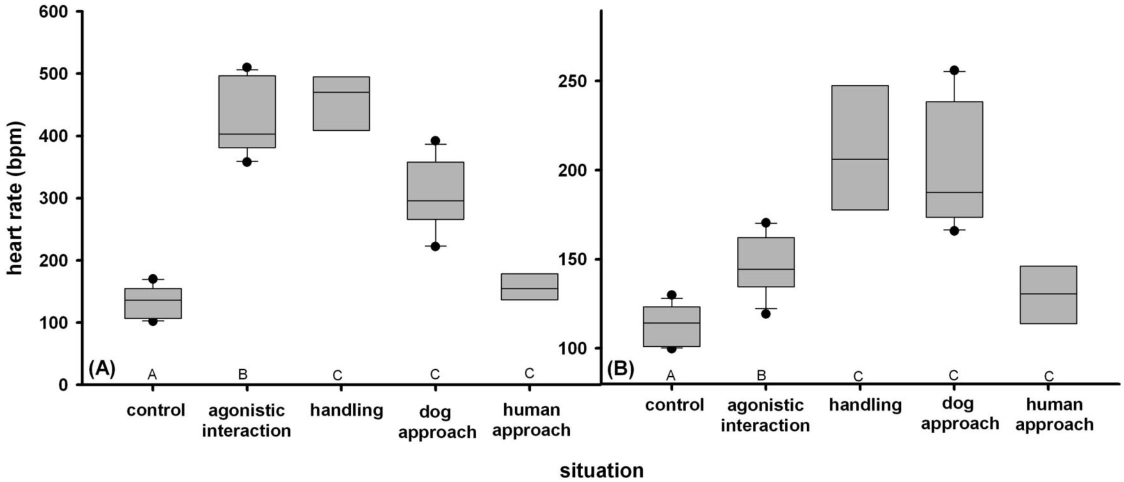

Figure 1. Maximum (A) and mean heart rate (HR; B) in beats per minute (bpm) during three different experimentally induced challenge situations (catching and holding, dog approach, human approach), the control period and agonistic encounters. Box plots show the median and the interquartile range from the 25th to the 75th percentiles. Whiskers above and below the box indicate the 10th and 90th percentiles.

Discussion

In the present study we aimed to confront greylag geese with different stressors under reasonably controlled conditions to measure their short-term HR responses. All three experimentally induced challenge situations caused a significant elevation in HR compared to a control period. These HR changes differed in magnitude between the various stressors. Catching and handling elicited the greatest responses in HR, followed by the approach of a leashed dog, as a predator model. Given this flexible modulation of the physiological stress response, we suggest an internal evaluation of a stressor preceding the HR modulation. This has been shown previously in social contexts (Wascher et al., 2009) and in the present study also in nonsocial situations. We suggest this flexibility of the stress response to be adaptive, as short-term elevations help an individual to deal with a given stressor, whereas frequent and long-term elevations of the physiological stress response are energetically costly. Therefore, individuals can avoid costly activation of the stress response, when the perceived risk of an event is low. One factor which seemed important in that respect is the controllability of the situation by the individual, which has been shown in lambs (*Ovis aries*, Désiré et al., 2006) and rats (*Rattus norvegicus*, Weiss, 1970). In our study, catching and handling, definitely presented the least controllable situation, as geese did not have the chance to escape. Here, HR increased to the highest maximum levels. In case of the approaches by humans or a leashed dog, the experiment was terminated before the geese took off. Therefore, the focal individual still had the

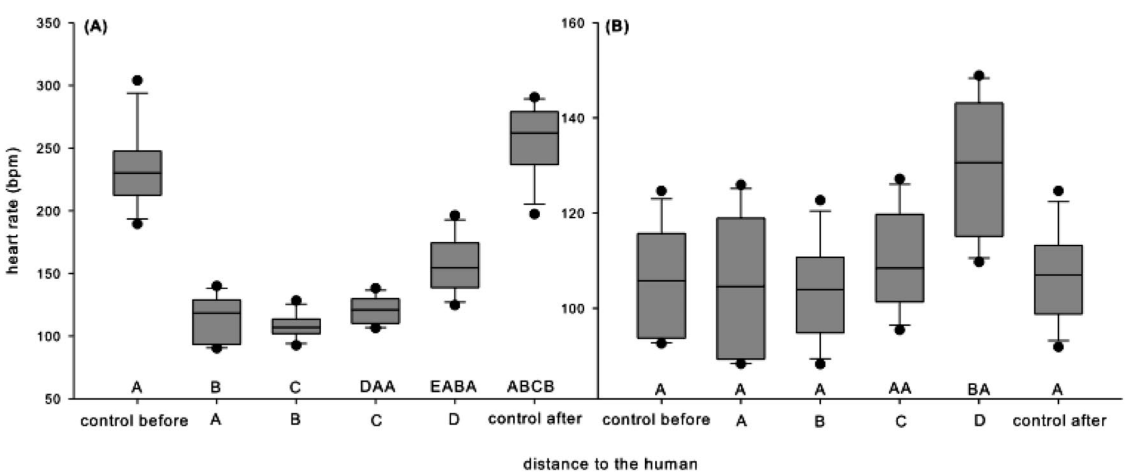

Figure 2. Maximum (A) and mean HR (B) in beats per minute (bpm) of seven greylag geese during human approach in four different distance categories and two controls before and after the experiment. The *x*-axis displays the distance to the human: A->3–2 m; B-2–1 m; C-1–0.5 m; D-0.5–0 m.

opportunity to "control" the situation by getting away. Still, HR increased to higher levels when being approached by a dog compared to a human. Obviously, a dog, which potentially could be a threat for a goose is perceived as more dangerous than a human, to which geese in the study population are well habituated.

In Experiment 3 greylag geese have been shown to be capable of discriminating familiar and nonfamiliar humans, as they showed a stronger physiological response to nonfamiliar humans, even if no change in the behavior of the geese was discernable to the human eye. Discriminative abilities of birds between different humans were shown before by Hüppop & Hagen (1990).

Overall, our results show that greylag geese not only discriminate between different kinds of stressors but also evaluate the individual relevance of any event and modulate their physiological response accordingly. This is essential in terms of an adequate response to short-term stressors, as immediate physiological as well as behavioral actions are required to cope with various stressors efficiently.

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