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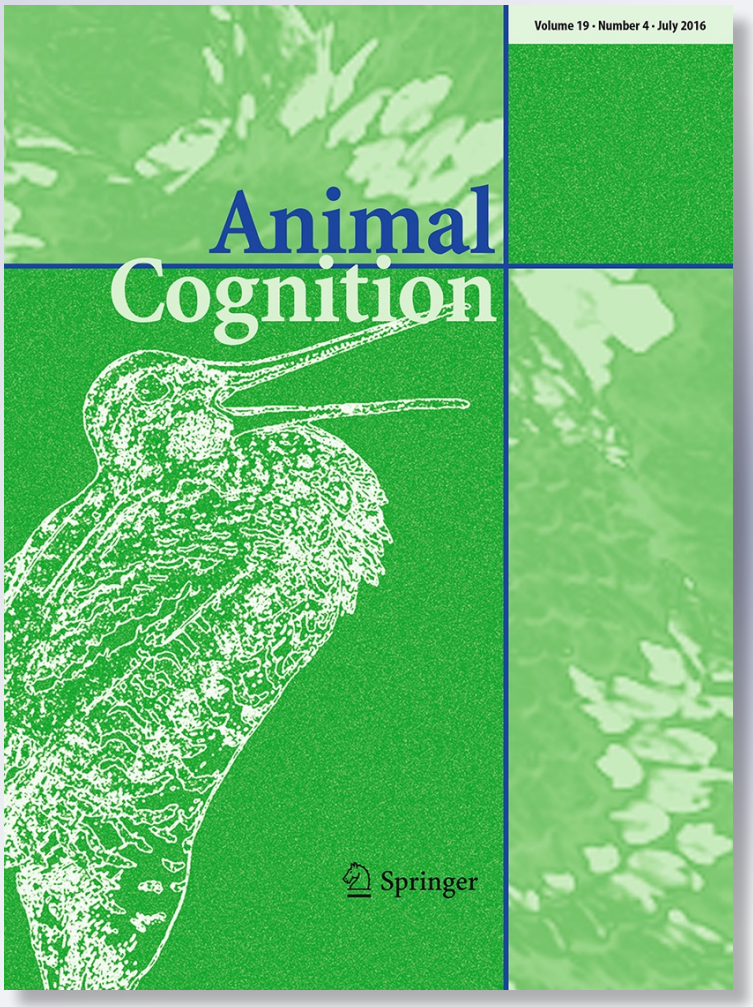

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SHORT COMMUNICATION

Antarctic skuas recognize individual humans

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Abstract Recent findings report that wild animals can recognize individual humans. To explain how the animals distinguish humans, two hypotheses are proposed. The high cognitive abilities hypothesis implies that pre-existing high intelligence enabled animals to acquire such abilities. The pre-exposure to stimuli hypothesis suggests that frequent encounters with humans promote the acquisition of discriminatory abilities in these species. Here, we examine individual human recognition abilities in a wild Antarctic species, the brown skua (*Stercorarius antarcticus*), which lives away from typical human settlements and was only recently exposed to humans due to activities at Antarctic stations. We found that, as nest visits were repeated, the skua parents responded at further distances and were more likely to attack the nest intruder. Also, we demonstrated that seven out of seven breeding pairs of skuas selectively responded to a human nest intruder with aggression and ignored a neutral human who had not previously approached the nest. The results indicate that Antarctic skuas, a species that typically inhabited in human-free areas, are able to recognize individual humans who disturbed their nests. Our findings generally support the high cognitive abilities hypothesis, but this ability can be acquired during a relatively short period in the life of an individual as a result of interactions between individual birds and humans.

Keywords Cognition · Human recognition · Pre-exposure · Brown skua · Antarctic bird

Introduction

Many wild animal species discriminate among individual humans. Two general hypotheses have been suggested to explain how wild animals discriminate individual humans among others (reviewed in Lee et al. 2011). One hypothesis is that high cognitive abilities may enable species to recognize individual humans ("high cognitive abilities hypothesis"). Comparative studies suggest that corvids and parrots have relatively large forebrains and have high cognitive abilities (Emery 2006) and empirical studies confirm that wild corvids recognize individual humans (Marzluff et al. 2010; Lee et al. 2011; Davidson et al. 2015). The other hypothesis proposes that pre-exposure to stimuli may facilitate the recognition of individual humans by animals ("pre-exposure to stimuli hypothesis"). This hypothesis explains that repeated interactions (pre-exposures) with individual humans (stimuli) may lead to the ability to differentiate between humans. According to this hypothesis,

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species from various taxa may learn to discriminate between individual humans regardless of the species' cognitive abilities (Davis 2002). Lee et al. (2011) suggested that these two hypotheses are not mutually exclusive, because more obvious effects of pre-exposure to stimuli are expected in species with higher cognitive abilities.

Individual human recognition behaviors have been reported in species that evolved near human habitats. In urban areas, wild animals may benefit from identifying humans who can do harm (Sol et al. 2013). This is supported by experiments involving nest approaches or trapping in urban habitats (Marzluff et al. 2010; Lee et al. 2011). Studies on species with high cognitive abilities, as well as those with poor cognitive abilities, are needed in human-free habitats in order to better understand the relative importance of cognition versus pre-exposure mechanisms in shaping the ability of birds to recognize individual humans.

Here we investigated human recognition abilities in a wild Antarctic bird, the brown skua (*Stercorarius antarcticus lonnbergi*). This species is distributed from the sub-Antarctic to the Antarctic, and its lifespan is approximately 30 years (Furness 1987). Our study site is located on King George Island in the Antarctic Peninsula, which is assumed to be a habitat with little human presence at least until the 1950s. Birds endemic to King George Island therefore evolved in an environment where contact with humans was extremely rare. At present (in 2015), 11 Antarctic stations belonging to 10 countries are being operated on King George Island, and 60–80 researchers visit King Sejong Station annually during the Antarctic summer. In 2013–2014 season, approximately nine people visit our study site per day. We hypothesized that wild Antarctic skuas would be able to recognize individual humans. First, we measured response distances to approaching humans who previously had access to their nests to determine if the incubating skuas recognize these humans at a greater distance with repeated visits. Second, we experimentally tested discriminatory ability with a pair of humans; one was the nest intruder who previously handled eggs and nestlings, and the other was a neutral human who had not approached nest sites before.

Methods

We surveyed the breeding status of brown skua pairs at Narębski Point (Antarctic Specially Protected Area No. 171 since 2009; 62°14.3′S, 58°46.5′W; 2 km away from a Korean station) on King George Island, Antarctica. About 10 breeding brown skua pairs have been annually recorded near a penguin rookery in this region since 2005. From early December 2014 to late January 2015, during the incubation and chick-rearing period, two researchers ("the intruders") visited the nest sites once a week to check the eggs and chicks. During the field survey, eight brown skua nests were recorded; one pair was found late at the end of the survey and was not included in the study. Each nest was visited for approximately 10–15 min once a week. On the first visit, researchers chose one linear route to approach the nest that was used throughout the breeding season and put small stones every 5 m (from 0 to 30 m) from the nest in order to mark the distances from the nest that can be used to estimate the response distances. When approaching the nests, the researchers walked at a speed of approximately 1 m/s and measured flush distance. The researchers also recorded the behavioral responses. Because the physical attacks were clearly distinguished from other responses, we used the presence/absence of the physical attacks as a sign of aggressive responses for the analysis.

With seven breeding pairs of brown skuas, we tested whether the birds distinguish the human who visited their nests earlier (intruder) from the other human who had never approached the nest sites (neutral human). This test was conducted once per nest on the fourth visit (4–5 weeks after egg-laying; near hatching); thus, seven trials were conducted in total. A pair of humans consisting of a nest intruder and a neutral human walked toward the incubating skua up to the point 5 m away from the nest. Then the humans waited for approximately 15–30 s until the other skua parent came. After both parents were present, the two humans walked in different directions for 20–30 m. A third person located over 40–50 m away recorded the responses of skuas using a camcorder (Online Resource 1 and 2, for movies). The two nest intruders were YD and SH. The two neutral humans were WY and JW in the experiments (Fig. 1c). The pair YD and WY approached three nests, the pair YD and JW approached two nests, the pair SH and WY approached one nest, and the pair SH and JW approached one nest. Responses of the skuas were coded as a binary variable: +1 was assigned if skuas directed their attacks to the nest intruder and −1 was assigned if skuas directed attacks toward the neutral human.

For statistical analyses, we used two generalized linear mixed models. First, we examined the effect of number of nest visits on the response distance, with nest identity as a repeated measure (PROC MIXED in SAS 9.3). Response distances ranged from 5 to 25 m (every 5 m). Four nests that produced nestlings successfully were visited seven times. In the other three nests, the eggs failed to hatch, and we stopped visiting these nests after the eggs disappeared; of these three nests, two were visited four times and one was visited five times. Second, we examined whether the probability of physical attacks (coded as a binary variable with "0" when no physical attack was observed or "1" when physical attack was observed) increased as the number of nest visits increased using generalized linear mixed model with a logit

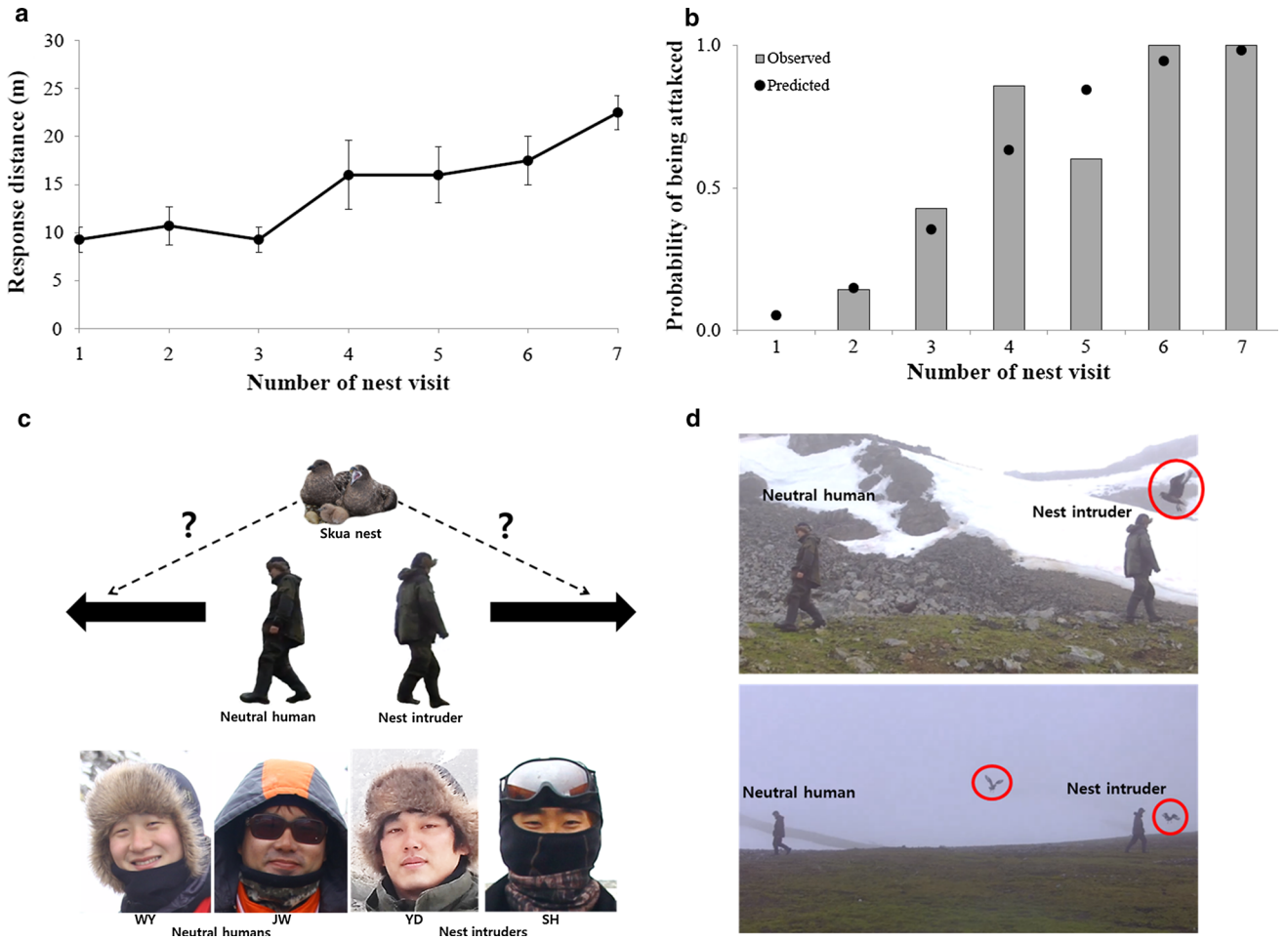

Fig. 1 Response distance of skuas to the approaching humans (*black dots* and a *linear line*; average ± SE) increased with the number of nest visit (**a**) and probability of being attacked (binary coded as "0" or "1"), involving physical threatening on human head, increased (*gray bars* from seven nests were observed values and *black dots* were predicted values) with the number of nest visit (**b**). Experimental design to test the discriminatory ability (**c**): a pair of humans in the discrimination experiments with (neutral human and nest intruder) and the faces of neutral humans (WY and JW) and nest intruders (YD and SH). Two examples of the experiments on skuas (*red circles*) were presented (**d**). In total seven trials (one trial in each nest), all seven skua pairs consistently followed the intruders and exhibited aggression (color figure online)

link function and binomial distribution (PROC GENMOD in SAS 9.3). Nest identity was included as a repeated measure. For the discrimination experiments, one-sample sign test was used to examine the discriminatory ability of skuas when a pair of humans (nest intruder and neutral human) approached to the nests. The identity of the approaching pair was not considered due to the small sample size for each pair. Since all pairs approached the nests in similar clothes, we assumed that considering the identity of the approaching pair in the analysis was not necessary.

Results

Response distances significantly increased as the intruder repeated the nest visits (Fig. 1a; GLMM, PROC GENMOD, Chi-square = 5.14, $df = 1$, $P = 0.02$). Skuas responded at 5–15 m away from the nests after the first visit, but they responded at a greater distance (10–25 m) after the fourth visit. Skua parents also increased the probability of showing aggressive behaviors such as physical attacks with their legs on the head of the intruder as nest visits were repeated (Fig. 1b; GLMM, PROC MIXED, $F = 20.11$, numerator $df = 1$ and denominator $df = 29$, $P < 0.01$). All seven pairs reacted very aggressively to the intruder after five visits.

In the discrimination experiments, all skua pairs ($N = 7$) clearly followed the nest intruder out of seven trials (Fig. 1c, d; one-sample sign test, $Z_6 = 2.65$, $P = 0.008$ when H_0: median = 0) and exhibited strong aggressive responses (for movies, refer Online Resource 1 and 2). Hence, our results indicate that the skuas discriminate nest intruders from the pair of humans and selectively responded to the nest intruders.

Discussion

Our results showed that brown skuas breeding in Antarctica discriminate between individual humans. The skuas increased aggressive defense behaviors toward the intruder with multiple human visits. Such elevated response implies that the parents perceived the approaching humans as a threat to their nests (Lee et al. 2011). The birds became highly aggressive at around hatching period when the researchers visited the nests 4–5 times. Also, this corresponds to the classic life history explanation that the birds increased the intensity of nest defense to predators during the breeding cycle (Montgomerie and Weatherhead 1988). Although it is not clear when the birds acquired the ability to recognize individual humans who previously threatened them, our discrimination experiments on the fourth nest visit with a combination of neutral and intruder humans showed that they distinguished the intruders from a neutral human. In the seven discrimination experiments, the researchers wore identical clothes (Fig. 1d). Thus, if they use visual information, we suspect that they may have used human faces and other features, including body postures, as the cue to distinguish between humans. Studies on corvids using facial masks revealed that the face may be an important cue (Marzluff et al. 2010; Davidson et al. 2015). In cold and windy environments like Antarctica, olfactory signals are less likely to play an important role in human recognition compared with visual traits.

It is interesting that an Antarctic species, which has not experienced human visits over a long evolutionary time, has the ability to recognize individual humans. This could be related to the apparent high cognitive abilities of skuas. Anecdotes of feeding–innovating behaviors in many skua species were reported, suggesting that this predatory species has relatively high cognitive abilities. Brown skuas have been recorded to chase other large birds and take food from them (Spear et al. 1999) and even to steal breast milk drops of nursing elephant seals, *Mirounga leonina* (Chester 1993). As suggested by Morand-Ferron et al. (2007), the occurrence of food stealing (kleptoparasitism) reflects high cognitive abilities. Is the ability to recognize individual humans exclusive to skuas or is it also present in other Antarctic birds? If cognition plays a role and if the skua with its flexible predatory strategies has indeed relatively higher cognitive abilities than other local breeders like sheathbills (*Chionis albus*) and Antarctic terns (*Sterna vittata*) that are also present near our field site, then the latter two species should not be as good at recognizing individual humans as skuas. Indeed, during our study period in 2014–2015 season, no particular discriminatory responses were detected in three sheathbill nests nor in the eight Antarctic tern nests when they were approached in similar manners (Han, unpublished data). Based on these findings, we think that high cognitive abilities hypothesis may explain the discriminatory abilities of skuas to recognize individual humans.

We cannot exclude the additional effects of pre-exposure to human inhabitants of the Antarctic stations, especially in a species with high learning abilities. It is possible that an individual skua gradually acquires its abilities to recognize individual humans from among humans present in the area during the bird's lifetime (about 30 years). Because six skua pairs out of the seven pairs we studied were captured and ringed in the 2004/2005 season, their ages would be more than at least 10 years. Also, they have been recorded annually near the station. If human contacts were enough to affect skuas, the pre-exposure hypothesis can fully explain the discriminatory behaviors of skuas. According to the predictions of pre-exposure hypothesis, regardless of the cognitive abilities, wild animals can show such behaviors. This site provides more chances for skuas to meet humans relative to Antarctic sites without stations, and the skuas could learn which particular humans harmed their nests. Considering the short history of human presence in Antarctica, it is difficult to believe that the recent human activities have exerted enough selection pressure to initiate the ability to recognize individual humans in this long-lived species. There have only been a few records of humans killing or maiming skuas near stations (Hemmings 1990). Hence, it is unlikely that the ability to recognize individual humans is an evolutionary adaptation to interactions with humans. That said, rapid learning by skua individuals from experiences with humans living at the Antarctic stations and exposure to the novel potential predators may be responsible for the observed abilities to recognize humans by this species of apparently high cognitive abilities.

This is the first study to demonstrate that Antarctic skuas from typically human-free habitats recognize individual humans. It appears that cognitive abilities of skuas promote learning of this skill by individual birds during their occasional interactions with humans inhabiting Antarctic stations. Future studies of similar abilities in several other Antarctic species will provide more clarity on the role of cognitive abilities in this phenomenon.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Ethical standards The experiments comply with the current laws of Republic of Korea.

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