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Social attention in keas, dogs, and human children

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Abstract

Understanding animals' abilities to cooperate with and learn from each other has been an active field of research in recent years. One important basis for all types of social interactions is the disposition of animals to pay attention to each other—a factor often neglected in discussions and experiments. Since attention differs between species as well as between individuals, it is likely to influence the amount and type of information different species and/or observers may extract from conspecifics in any given situation. Here, we carried out a standardized comparative study on attention towards a model demonstrating food-related behavior in keas, dogs and children. In a series of experimental sessions, individuals watched different conspecific models while searching, manipulating and feeding. Visual access to the demonstration was provided by two observation holes, which allowed us to determine exactly how often and for how long observers watched the model. We found profound differences in the factors that influence attention within as well as between the tested species. This study suggests that attention should be incorporated as an important variable when testing species in social situations.

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Keywords

Attention; Species comparison; Children; Keas; Dogs; Social learning experiments; Observing conspecifics

Introduction

One crucial aspect of living in a socially complex society is paying attention towards other group members, their interactions and behaviors. Monitoring the behavior of others enables an individual to make better decisions in regards to cooperation, competition, communication as well as social learning. However, time and/or habitat constraints might restrict the opportunity to observe every other animal within the group or every action performed, forcing animals to be selective in regards to whom and what to observe. Selectivity is likely to be dependent on the sex, age and affiliative pattern of the observer and model as well as on several aspects of the social structure and life history of a species (Choleris et al. 1997; Choleris and Kavaliers 1999; Valsecchi et al. 1993; Day et al. 2003; Nicol and Pope 1999; Moscovice and Snowdon 2006; Gajdon and Stauffacher 2001). Thus, the focus of attention as well as attention parameters in themselves might vary considerably among individuals and even species.

Cohen (1972) differentiated between two attention processes, which are relevant for observing the behaviour of others to extract important information. The attention-getting process determines whether or not the subject will turn to look at a stimulus. The attention-holding process determines how long the subject will continue to gaze at a stimulus once it looked. Thus, in order to extract information, an observer might look at another individual’s behaviour a few times for very short durations or once or twice for a longer duration. In the latter case, the observer is likely to learn more about the sequence and coordination of actions and potentially the consequences and the causal relationship between actions than if the observer looks often but for only very short periods.

In two previous studies, we investigated the attention pattern of common marmosets (Range and Huber 2007), ravens and jackdaws (Scheid et al. 2007) in a social learning paradigm. We were interested how much and for how long individuals would observe a model while searching, manipulating or feeding as well as how age, sex and familiarity influenced attention of individual animals. To further investigate observing behaviour, here we tested two additional mammalian and one avian species known for their complex social life and sophisticated cognitive skills: humans *Homo sapiens* (preschool-children), domestic dogs *Canis familiaris*, and keas *Nestor notabilis*. All three species live in societies structured by age, dominance, kin and friendship relations (keas: Diamond 1991, Diamond and Bond 1991, 1999; children: Rubin et al. 1997, Howes 1988; dogs: Ginsburg 1991), in addition dogs may be exceptional for their ability of forming close social bonds not only with conspecifis but with their human owners (Kubinyi et al. 2003). Notably all three species are capable of higher forms of social learning and of using others as social tools. For instance, dogs can imitate (Range et al. 2007), they comprehend communicative signals given by humans (McConnell and Baylis 1985; Miklosi and Soproni, 2006) and actively make use of their owners to gain access to food that is out of reach (Miklosi et al. 2000; Viranyi et al. 2006). Keas have been shown to learn about outcome of motor tasks through emulation (Huber et al. 2001) and to selectively manipulate conspecifics to gain access to enclosed food (Tebbich et al. 1996). Human children are exceptional in their ability to imitate, share attention, and cooperate (Tomasello 1999; Tomasello et al. 2005).

Using a comparable experimental set-up, we examined (1) which parameters influence attention within the different species and (2) how attention towards conspecifics differs between species. Like in the previous experiments, we measured their direct attention to the model by providing restricted visual access through two holes to the demonstration compartment, which allowed for measurements of attention-getting and attention-holding. The rationale for using a two-hole procedure is that if animals are interested in the actions of the model, they will look through one of the two holes during the demonstration. Two holes are provided to allow some flexibility for the observer in regards to the angle of vision as well as position within his own compartment.

We predicted that individuals would be more attentive (frequency and duration of looks) when the model was engaged in activities that might potentially provide useful information to the observer (e.g. manipulation of an object, eating specific food) compared to activities like exploring the surroundings. Furthermore, we expected that individuals would vary in their attention according to the model. Specifically, we expected (1) that age would have an effect on attention with younger observers watching more than older observers and (2) that dogs would be more attentive towards a human than a dog model based on their evolutionary history of domestication or their developmental training by humans. Finally, we thought human children would be more attentive than any of the other species.

Methods

General experimental set-up

The model/observer studies were comparable as much as possible for all species in the general set-up. Two individuals (the model and the observer) were locally and in the case of the dogs and the keas visually separated from the other group members. In the children study, a visual separation was not possible; however, the other children were occupied with playing during the experiment to avoid that they would distract the observer. The model and observer were tested in two compartments, an observation chamber and a demonstration chamber (Fig. 1). The two chambers were divided by an opaque wall with two holes, through which the observers had visual access to the model compartment. All subjects were familiarized to the experimental setting before the tests started: Dogs were called to look through each hole without being rewarded and keas, being very curious, had a habituation period when they could investigate the two new holes in their aviary. All experiments were conducted in summer 2006.

Keas

Subjects—We used nine captive born male keas as subjects. Five were juveniles (1–1.5 years old) and four were adults (2.5 years and older) at the time of testing. They were housed in a large outdoor aviary (15 × 10 m and 4 m high) that could be divided into three compartments. All compartments were equipped with tree trunks, rocks, pieces of wood, perches and wooden shelters and the ground was covered with sand. Water and food, which contained a mixture of vegetables, fruits, seeds, butter, meat and vitamin supplements every day, were available ad libitum. Individual recognition of the birds was facilitated by coloured leg bands.

Experimental set-up—The middle and right compartment of the aviary were used as the observer and model compartment respectively. To prevent the observers from watching from the side or above, a wooden shed (2 m × 2 m × 2 m) was built in the model compartment with the back wall bordering the wire-mesh partition. Two round holes (4 cm in diameter) were cut in the vertical center of the back wall; both were at the same height, 25 cm from the bottom. The keas walked along the ground to look through the holes. A metal container (50 cm × 100 cm), Wlled with a 3 cm high layer of wood chips, was put into the model compartment. The camera was positioned outside the aviary.

Procedure—Every individual served as model and observer in every possible dyad. Individuals were tested once per experimental day and roles (model vs. observer) were alternated between days. Tests were conducted every two to three days. At the beginning of a test session, the model was allowed to watch the experimenter put a piece of food (butter or cottage cheese) into the film canister and bury that canister under the wood chips in the model chamber. The film canister was attached with a wire to the bottom of the metal box to prevent the keas from flying away with the canister. After the canister was buried, the experimenter (FR) moved wood-chips with her hands in several other places within the metal container to avoid that the model just searched the last place touched by the experimenter to locate the hidden film canister. The model watched the burying process from approximately 1.5 m. After the food was hidden, the experimenter opened the observation holes and knocked against the wall and called the observers name to get its attention. Then the model was allowed to enter the model chamber and search for the film canister. The session ended once the food was retrieved and eaten. Kea observers usually used only one eye to look through the holes; thus using only one Weld of vision.

All sessions were videotaped with a digital camera (Sony DCR—TRV 25E) that focused on the behaviour of the model and on the two observation holes. In a frame-by-frame analysis, we analyzed the duration the model spent searching, manipulating or feeding. For the observer, the duration and number of looks while the model was searching, manipulating, feeding or engaged in other behaviour were recorded. Searching was defined as moving slowly forward while visually scanning the floor, occasionally moving wood chips with the beak. Manipulating was defined as being in physical contact with the film canister, trying to open it with the claws or beak. Feeding was recorded when the model put the food item into its beak and swallowed it.

Dogs

Subjects—Dogs (N = 38) and their owners were recruited during a summer dog training camp in Hungary. Participation in the tests was voluntary. Owners were instructed what to do and what to say during the test. We only included dogs in the analyses if the owner acted in line with our instructions. Only dogs older than 6 months were tested (mean age: 5.15 years, range: 6 months–12 years), and various breeds were included. The overall sex ratio of dogs was balanced (male to female: 17–21).

Experimental set-up—With five wooden boards (1 m × 1 m) we constructed a closed observation chamber and an open model chamber (Fig. 1). In the partition wall, two holes (6.5 cm in diameter) were cut at different heights (28 and 50 cm) since we tested different breeds that varied considerably in size. On the side of the model compartment, we dug a hole (50 cm wide × 70 cm long × 20 cm deep) that was filled with wood-chips.

Procedure—Dogs were randomly assigned to two experimental groups: human and dog model. Within the human model group, each subject (n = 20) was tested with his/her owner and a non-familiar human as model on two consecutive days. In the dog model group, each subject (n = 18) was tested with a female and a male dog as the model. We used a total of two familiar female and two familiar male model dogs. Thus, in that respect the procedure was different in comparison with the kea and children study, where each subject was tested as model and observer.

The sequence of demonstration was counterbalanced within groups. Observer and model dogs were familiarized prior to the experiment.

Model dogs were trained to search for a tightly crumbled piece of paper buried in the wood chips, rip the paper apart and then chew the reward hidden inside. The human models were instructed to do the same as the dog models with each phase (searching, manipulating and feeding) taking about 30 s.

Unless the owner was the model, he/she was standing 1 m behind the subject during the test, refraining from any communication with the dog. The experimental protocol in itself was identical to the one used for the keas except that the model dog was not allowed to watch the paper being buried, because when they watched, dogs did not search at all.

Children

Subjects—The subjects were 40 children in the age of 3–6 years (mean age 4.55 years; 20 boys and 20 girls) recruited from a kindergarten in Vienna, where the experiments took place. Parents were informed about the whole project and consented in the participation of their children.

Experimental set-up—The experiments took place between one group room (observer compartment) and its connected bathroom (model compartment) (Fig. 1b). The door between the two groups had a glass strip in the middle and was used as the partition wall. The glass strip was partly covered with wrapping-paper to obtain two rectangular holes (25 cm × 10 cm) in the horizontal center, 40 and 80 cm from the bottom respectively. The observer compartment was separated from the rest of the group room with chairs to prevent disturbing the other children during the experiments. In the model compartment (bathroom)

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a carton with 26 little film canisters was positioned on the ground. A blanket and cushions were provided for the model to sit on.

Procedure—The children were divided into two age groups (3–4 and 5–6 years old) with 20 children each. Every child served as a model as well as an observer with a “same sex model”, an “opposite sex model” and an “adult model”. Thus, individuals were tested thrice as observer and twice as model.

In the beginning of a test, observer and model were guided into the observer department, where the observer was told to wait in this compartment for his/her turn. The model was guided into the model compartment through the observation door, where it was quietly told (inaudible to the observer) to search for a film canister with a certain picture on it, to open and eat the piece of sweet in it. Otherwise the procedure was identical to the other two studies.

Data analysis—During the tests, the model could either be engaged in searching, manipulating or feeding (referred to as ‘food-directed behavior’) or investigate the model compartment. Since the latter occurred in several trials with keas (18.3% of all trials) and dogs (24.4% of all trials), we analyzed for these two species the behavior of the observers while the model was investigating the model compartment. We calculated the percentage of time the observer was attentive (e.g. looking through either one of the observation holes) to a searching, manipulating, feeding or investigating conspecific (e.g. duration looking/time model searching × 100). Furthermore, we calculated the number of looks through the two holes while the model was engaged in either of the food-directed behaviors (e.g. number of looks during time model is searching). If we found a significant difference in the duration models were engaged in the different food-directed behaviors, we calculated the frequency of looks per second instead (e.g. number of looks/time model is searching). Finally, we calculated the mean duration of looks as the sum of the durations of all looks during a specific activity of the model divided by the number of looks during that activity. Although not independent of each other, we report all three measurements since the percentage of observation time could be high because an animal is watching frequently for short durations or seldom but for long durations, which might have different effects on the outcome of an experiment. Unfortunately, it was impossible to record the exact eye gaze of the animals. Thus, all reported measurements are likely to overestimate the actual attention to the model and its activity.

Videotapes were analysed by L. Horn and M. Hüffel. To confirm scoring consistency between the three observers, F. Range also analysed 9–10 model and observer videos of the dogs, keas and children. Pearson correlations revealed high interobserver reliability in the duration of searching, manipulating and feeding of the model and the observers’ duration of looking for the keas (Pearson correlations: **Model**: Searching: $N = 10$; $r_p = 0.98$; $p < 0.001$; Manipulating: $N = 10$; $r_p = 0.76$; $p = 0.01$; Feeding: $N = 10$; $r_p = 0.67$; $p = 0.03$; **Observer**: Searching: $N = 10$; $r_p = 1.00$; $p < 0.001$; Manipulating: $N = 10$; $r_p = 0.95$; $p < 0.001$; Feeding: $N = 10$; $r_p = 0.9$; $p < 0.001$); the dogs (Pearson correlations: **Model**: Searching: $N = 10$; $r_p = 0.622$; $p = 0.055$; Manipulating: $N = 10$; $r_p = 0.93$; $p = 0.001$; Feeding: $N = 10$; $r_p = 0.99$; $p = 0.001$; **Observer**: Searching: $N = 10$; $r_p = 0.97$; $p < 0.001$; Manipulating: $N = 10$;

$r_p = 0.99$; $p = 0.001$; Feeding: $N = 10$; $r_p = 0.99$; $p = 0.001$) and the children (Pearson correlations: **Model:** Searching: $N = 9$; $r_p = 0.99$; $p = 0.000$; Manipulating: $N = 9$; $r_p = 0.98$; $p < 0.001$; Feeding: $N = 13$; $r_p = 0.67$; $p = 0.05$; **Observer**: Searching: $N = 9$; $r_p = 0.99$; $p = 0.000$; Manipulating: $N = 9$; $r_p = 0.99$; $p < 0.001$; Feeding: $N = 9$; $r_p = 0.97$; $p < 0.001$).

Statistics—Before statistical analyses we tested the parameters for normality using a Kolmogorov–Smirnov test. Since none of the parameters in the three study species was normally distributed, we used nonparametric statistics to analyze all data. In the result section, we present the median (1. quartile; 3. quartile) across all animals, when referring to the percentage observation, the number of looks or the duration. If, for a given analysis, several trials of the same animal were analyzed, the mean for each animal was calculated first. All statistical analyses were performed with GraphPad InStat (Version 3.06; GraphPad Software). All tests were two-tailed and α was set at 0.05.

Results

Keas

Activity of the model—Overall, the models differed in the duration of investigating, searching, manipulating and feeding (Friedman: Fr = 14.467, $N = 9$, df = 2; $p = 0.0023$). Dunn's multiple comparison test revealed that models spent more time feeding compared to investigating ($p < 0.05$) searching ($p < 0.05$) and manipulating ($p < 0.01$).

Differences in attention according to the activity of the model—Overall, observers paid attention to the model 24.49 (14.30; 49.40)% of the time the model was present in the model compartment. They showed more interest towards the model when it was engaged with searching, manipulating or feeding (i.e. food-directed) than when it was engaged in investigating the model compartment (Wilcoxon signed-ranks test: % observation: $T+ = 1$, $N = 9$, $p = 0.0078$). Keas differed in attention according to whether the model was searching, manipulating or feeding in the frequency of looks (Friedman: Fr = 6.889, $N = 9$, df = 2, $p = 0.031$) and in the mean duration of looks (Friedman: Fr = 13.556, $N = 9$, df = 2, $p = 0.0003$), but not in the percentage of observation time (Friedman: Fr = 2.667, $N = 9$, df = 2, $p = 0.329$). On average, keas looked longest when the model was feeding compared to searching (Dunn's multiple comparison test, $p < 0.01$) and manipulating (Dunn's multiple comparison test, $p < 0.01$; Table 1). However, they looked more frequently when the model was manipulating than feeding (Dunn's multiple comparison test, $p < 0.05$). This difference is due to keas often watching continuously when the model was feeding, whereas in the other conditions they often went away after a short look to return a few seconds later to look again.

Age differences in attention of the observers—The variance in attention between individuals was large with one individual watching on average (±SD) as little as 13.76 ± 14.89% of the model's handling time, whereas another individual watched on average as much as 62.25 ± 20.65%. Age did not explain significantly the differences in attention in the percent observation time (Mann–Whitney-U Test: % observation: $U = 2.000$, $N_A = 4$, $N_J = 5$, $p = 0.063$). Juveniles (J) neither look significantly more often than adults (J) nor for a longer duration (Mann–Whitney-*U* Test: looks: $U = 2.000$, $N_A = 4$, $N_J = 5$, $p = 0.063$; duration: $U = 10.00$, $N_A = 4$, $N_J = 5$, $p > 0.99$).

Habituation effects—Some of the animals were first the model and then the observer, whereas others were first the observer and then the model, thus it is possible that the sequence had an influence on observation in their first trial being an observer. However, we found no significant effect (Mann–Whitney-*U* Test: $U = 5.000$, $N_M = 6$, $N_O = 3$; $p = 0.36$) in % observation time between birds that were first models (M) or first observers (O) in their first observation trials. Moreover, as each individual was tested with every other animal in the group, individuals watched the same type of demonstration eight times. This raises the possibility that animals lost interest in attending to the demonstrations over time. However, we found no habituation effects across experimental sessions in the percentage observation (Friedman: Fr = 3.293, $N = 9$, df = 7, $p = 0.856$) and number of looks (Friedman: Fr = 8.310, $N = 9$, df = 7, $p = 0.2163$) suggesting that individuals attended to the demonstration as much in the first as in the last sessions.

Effect of the model—The juveniles spent the same percent of the observation time watching adult and other juvenile model birds [48.58 (48.43; 53.03) and 39.34 (38.69; 53.37)% respectively]. The adult birds, on the other hand, watched more if the model was another adult [23.19 (20.77; 31.21)% observation time] than when it was a juvenile [9.33 (7.00; 11.1)% observation time]. Due to the small sample sizes, no statistics were calculated.

Dogs

Activity of the model—In the human model group, only four humans investigated the model compartment during the demonstration. Furthermore, there was no significant difference between the duration the model was searching, manipulating and feeding (Friedman: Fr = 3.7, $N = 20$, df = 2; $p = 0.157$). In contrast, dog models differed significantly in the duration of the three activities (Friedman: Fr = 31.0, $N = 18$, df = 2; $p < 0.0001$). Dunn's multiple comparisons test revealed that they spent more time feeding than searching ($p < 0.001$) and manipulating ($p < 0.01$). Dog models investigated the model compartment in 15 of the 38 demonstrations. We found no significant difference between the human (H) and the dog (D) models in the total duration of the demonstrations (Mann–Whitney-*U*: $U = 127.5$, $N_H = 20$, $N_D = 18$ $p = 0.129$).

Differences in attention according to the activity of the model—Overall, observers paid attention to the model 12.25 (7.18; 24.42)% of the time the model was present in the model compartment. They showed more interest towards the model when it was engaged with searching, manipulating or feeding (i.e. food-directed) than when it was engaged in investigating the compartment (Wilcoxon signed-ranks test: % observation: $T+ = 13$, $N = 13$, $p = 0.0215$). However, in regards to the food-directed behaviour, dogs differed according to the model species:

Human model: Dogs did not differ in attention according to whether the model was searching, manipulating or feeding in the percent observation time (Friedman: Fr = 0.7, $N = 20$, df = 2, $p < 0.705$) nor in the mean duration of looks (Friedman: Fr = 3.5, $N = 16$, df = 2,

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$p < 0.1738$). However, they differed in the number of looks (Friedman: Fr = 8.361, $N = 20$, df = 2, $p = 0.015$) looking more often when the model was searching than feeding (Dunn's multiple comparison test; $p < 0.05$).

Dog model: When the model was a dog, dogs differed significantly in attention according to whether the model was searching, manipulating or feeding in the percent observation time (Friedman: Fr = 17.485, $N = 18$, df = 2, $p < 0.0002$) and the frequency of looks (Friedman: Fr = 20.576, $N = 18$, df = 2, $p < 0.0001$), but not in the mean duration of looks (Friedman: Fr = 0.6, $N = 10$, df = 2, $p = 0.83$)(Fig. 2). Dunn's multiple pair-wise comparison tests revealed that observers looked more frequently and for a higher percentage when the model was searching rather than manipulating ($p < 0.05$; $p < 0.05$ respectively) and feeding ($p < 0.001$; $p < 0.001$ respectively).

Differences in attention according to the identity of the model—Observers paid more attention to the human model [18.06 (10.73; 30.36)% observation time] than to the dog model [7.7 (5.26; 14.28)% observation time]((Mann–Whitney-*U*: $U = 94$, $N_H = 20$, $N_D = 18$ $p = 0.013$). This difference was mainly due to longer duration of looks in the human model group [3.98 (3.18; 5.20) s] compared to the dog model group [2.53 (1.87; 3.50) s] (Mann–Whitney-*U*: $U = 82$, $N_H = 20$, $N_D = 18$ $p = 0.008$) and not to a difference in the number of looks (Mann–Whitney-*U*: $U = 119.5$, $N_H = 20$, $N_D = 18$ $p = 0.079$).

Human model: The median (quartile 1–3) percentage of observation time during food-directed behaviour was only a little higher if the model was the owner (22.38 (10.18; 42.97)%] than if it was a stranger [14.96 (4.16; 19.99)%], but not significantly (Wilcoxon signed-ranks test: % of observation time: $T+ = 156$, $N = 20$, $p = 0.058$). There was also no difference between the two conditions in the number of looks or in the mean duration of looks (Wilcoxon signed-ranks test: number of looks: $T+ = 86$, $N = 20$, $p = 0.135$; mean duration of looks: $T+ = 145$, $N = 20$, $p = 0.1429$).

Dog model: We found no difference in the attention of observer dogs in regard to whether the model was of the same or opposite sex (Wilcoxon signed-ranks test: % of observation time: $T+ = 79$, $N = 18$, $p = 0.926$; frequency of looks: $T+ = 72$, $N = 18$, $p = 0.854$; mean duration of looks: $T+ = 74$, $N = 18$, $p = 0.454$).

Children

Activity of the model—Overall, the models differed in the duration of searching, manipulating and feeding (Friedman: Fr = 43.512, $N = 41$, df = 2; $p = 0.0001$). Dunn's multiple comparison test revealed that models spent more time feeding compared to searching ($p < 0.001$) and manipulating ($p < 0.001$).

Differences in attention according to the activity of the model—Overall, observers paid attention to the model 34.48 (20.79; 56.24)% of the time the model was present in the model compartment. The children also varied in their attention in relation to the model's activity in the mean duration of looks (Friedman: Fr = 9.548, $N = 31$, df = 2, $p = 0.008$) and in the frequency of looks (Friedman: Fr = 13.232, $N = 40$, df = 2, $p = 0.0013$), but not in the percentage of observation time (Friedman: Fr = 0.38, N = 40, df = 2, p = 0.830). On average, children looked longer when the model was searching or manipulating compared to eating (Dunn's multiple comparison test: $p < 0.05$ and $p < 0.05$ respectively) and more frequently if the model was searching compared to eating (Dunn's multiple comparison test: $p < 0.05$) (Table 1).

Age differences in attention of the observers—Individuals differed in how attentive they were towards the demonstration with some children not watching at all and others watching as much as 72.05–90.59% of the total time. Age (3–4 year olds and 5–6 year olds) did not explain the observed differences in attention (Mann–Whitney-*U*-Test: % observation: U = 166, $N_{3–4\ J}$ = 20, $N_{5–6\ J}$ = 20, p = 0.365; mean duration of looks: U = 129, $N_{3–4\ J}$ = 18, $N_{5–6\ J}$ = 18, p = 0.305; frequency of looks: U = 174.5, $N_{3–4\ J}$ = 20, $N_{5–6}$ J = 20, p = 0.4986). However, boys (B) watched the demonstration for significantly longer duration of looks than girls (G) (Mann–Whitney-*U*-Test: % observation: mean duration of looks: U = 93, NB = 18, NG = 18, p = 0.03; Fig. 3), but not for a higher percentage (Mann–Whitney-*U*-Test: % observation: U = 135, N_B = 20, N_G = 20, p = 0.08) or with a higher frequency of looks (Mann–Whitney-*U*-Test: U = 191, NB = 20, NG = 20, p = 0.818).

Effect of the model—Children showed only a slight and not significant increase in the duration of their looks if the model was a peer [(13.1 (10.39; 22.86) s] rather than an adult [11.21 (7.7; 15.58)] (Wilcoxon signed-ranks test: mean duration of looks: T+ = 67, N = 22 p = 0.054) and did not look longer overall (Wilcoxon signed-ranks test: % observation time: T+ = 232, N = 40, p = 0.267). Children did not differentiate in their attention according to whether the model was of the same or opposite sex (Wilcoxon signed-ranks test: % observation time: T+ = 230, N = 32, p = 0.531 mean duration of looks: T+ = 86, N = 20, p = 0.498).

Comparison across species—When we compared attention towards a conspecific across the three study species, we found a significant difference in both the percent of observation time (Kruskal Wallis Test: KW = 17.297, $p < 0.0002$) and the mean duration of looks (Kruskal Wallis Test: KW = 41.209, $p < 0.0001$). However, keas differed neither in the percent observation time nor mean duration of looks from the children (Fig. 4a). Interesting though, is the very high variance of the percent observation time in the children compared to the other species, indicating that several of the children showed extremely high interest in the demonstration, whereas others showed none. In regards to the mean duration of looks, clear differences were found between the three species with children and keas looking longer than dogs (Fig. 4b). Interestingly, we found that in the case of the children, subjects that looked more often also looked for a longer duration (Spearman Rank: r = 0.55, n = 40 p = 0.0002), this was not true for the dogs (Spearman Rank: r = 0.26, n = 38, p = 0.11) nor the keas (Spearman Rank: r = 0.25, n = 9, p = 0.52).

Discussion

All species readily used the holes provided to look into the demonstrator compartment, confirming previous studies that this set-up is a valuable paradigm to test attention in different species. The results presented here support our assumption that observing

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behaviour of keas, dogs and children in a situation similar to a social learning testing procedure is dependent on several factors such as the behaviour and age/sex/identity of model (Table 2); however, the relative importance of these different factors appears to differ between species. Keas paid more attention to a model if it was feeding rather than searching or manipulating. Moreover, juveniles were more interested in the demonstration than adults and not selective in regards to whom they watched—peer or adult—in contrast to the adults. Dogs paid more attention towards a human than towards a dog model and rather quickly lost interest, especially in the dog demonstration. Children were more attentive towards models that were searching and manipulating compared to eating. Age did not explain the high variation in attention levels of the children, but boys watched significantly longer than girls. These differences between conditions are a good indication that the test subjects paid attention to the behaviour of the models and not solely to some features in the demonstration room. Finally, when comparing attention levels across species, we found that children and keas watched the demonstration for a higher percentage and longer duration than dogs. Overall, most differences within and between species were found in the attention holding rather than the attention getting processes.

Keas

The only exception in the tested non-human species was that looks of keas at feeding models lasted for about as long as the looks of children. There might be several reasons for this behaviour. Keas might have simply looked more when the food was visibly present. However, since we baited the film canisters with butter and cottage cheese, the food was hardly ever clearly present, but instead the keas put their beak into the canister and licked out the bait. Thus, that merely the presence of the food is responsible for the observed results in unlikely.

Alternatively, keas might have a stronger predisposition to pay increased attention to what conspecifics are feeding on because they are more dependent on emergence of seasonal, probably unknown food sources in their mountainous/subalpine habitat than the other species are (Diamond and Bond 1999). This might be especially important for young keas that stay in loose flocks and get access to food by displacing other juvenile and adult birds (Diamond and Bond 1991). The fluffing of their feathers when doing so indicates their high level of excitement. Possibly, this excitement might have prevented young keas from terminating their watching of the feeding conspecifics even though they could not get close to the food site in this study.

Beside the mechanisms needed to maintain attention, mechanisms are also required to enable an appropriate shift of attention. This goes along with inhibitory control to attend to previously rewarded events. Kea might take especially long to develop such inhibitory mechanisms and thus might continue to stare at feeding conspecifics. For example, it takes them until eight months of age - the longest time known from any bird species so far - to abandon A-not-B-errors in tasks of object permanence (M. Pesendorfer, Gajdon und Huber unpublished data). Studies testing monkeys and children showed that A-not-B-errors decrease with the beginning functionality of parts of the frontal lobe that are considered to inhibit actions (Diamond 1991).

Furthermore, attention levels also differed on the individual level with some animals watching more than 50% of the demonstration, whereas others watched less than 10%. Age would have been expected to influence attention levels, because social learning facilitates the access and processing of difficult foods in infants (Fragaszy and Visalberghi 2004). The fact that we did not find higher attention levels in the juveniles could be due to the small sample size. Interestingly though, the age of the model did have an influence with adult observers that were only attentive if the model was also an adult animal. Two alternative hypotheses could explain this behaviour. First, the adult animals may have more differential relationships than young birds, forming closer bonds with same age peers. Close relationships may increase the interest and thus attention directed towards those animals. Several studies have found an influence of familiarity on the pattern of transmission of socially acquired behaviours (hens, *Gallus gallus domesticus*, Nicol and Pope 1994; chimpanzees, *Pan troglodytes*, Menzel 1973, 1974; Japanese macaques, *Macaca fuscata*, Nishida 1987). Alternatively, adult birds may have learned that information from older animals is more reliable and worthwhile to observe in contrast to the behaviour of younger animals. Further studies are necessary to test these two hypotheses.

Dogs

Dogs were most attentive during the searching phase of the dog model, with respect to the frequency of looks rather than the duration. This might suggest that the dogs were primarily interested in the identity of the model and maybe its general behaviour, checking often what was happening on the other side of the wall, but losing interest quickly. A decrease in looks over the phases was also observed in the human model condition albeit not as strongly. Alternatively, dogs are most interested in searching models rather than manipulating or feeding models.

In general, social learning and thus attention to a model is expected to occur in circumstances in which the observer can acquire some new knowledge, for example about predators (Mineka and Cook 1988), spatial utilization (Warner 1988), or what food is palatable (reviewed in Byrne and Russon 1998; Fragaszy and Visalberghi 1990, Visalberghi and Addessi 2000a, b, Visalberghi et al. 2003). However, due to their evolutionary history of domestication and their training by humans, these aspects might not be relevant for dogs anymore, since they usually rely on humans to solve their problems (Miklosi et al. 2003, Hare et al. 2002). Accordingly, dogs were also significantly more attentive and looked much longer if the model was a human and not a dog. Although, one would expect higher attention towards humans than dogs based on the domestication process and individual training, this does not necessarily mean that dogs learn more or better from a human model compared to a trained dog (Pongracz et al. 2004). Interestingly, we did not find a significant difference in attention towards owner or stranger, which is in line with detour experiments showing that strangers and owners were equally good as models (Pongracz et al. 2001).

Children

In children, a second attention system besides the one postulated by Cohen (1972); see also (Porges and Smith 1980) emerges at the end of the fist year of life, namely the higher level control system (Ruff and Rothbart 1996). It gradually increases its influence on attention throughout the preschool years. According to Ruff and Rothbart (1996), this development is a part of the larger construct of self-regulation.

To date, several studies have investigated for how long children pay attention to a television or during free play with toys. Under these conditions, the children's proportion of looking time generally increases in the course of the first years of life (Anderson and Levin 1976; Ruff and Lawson 1990, Ruff and Rothbart 1996). For example, in a study conducted by Ruff et al. (described in Ruff and Rothbart 1996), attention increased as a function of age with children of 2.5 years spending a significantly shorter proportion of time looking than children of 3.5 years of age. Interestingly, no increase in attention occurred thereafter. Similarly, we found an age dependent increase of observation time in infants from 20 to 35 months of age in a pilot study using basically the same, slightly adapted, methodology as the one presented in this paper (unpublished data). In Ruff et al.'s study, the proportion of looking was generally high (between seventy and ninety percent) and well above the range of observation time obtained in the present study. The duration of focused attention was doubled to up to twenty-five percent at 3.5 years of age and reached thirty percent at 4.5 years of age. These values closely match the ones obtained in the present study. Looking through a hole requires more active involvement than, for example just glancing at a television, but it is questionable whether peeping corresponds to focused attention once the subject got into the position in front of the hole.

Species comparison

The species differences in the mean duration of looks suggest that animals do not acquire the same level of control on attention as children do (with the possible exception of keas watching a feeding conspecific). The positive correlation between attention-getting (frequency of looks) and attention holding (duration of looks) processes in the children but not in the non-human species might further indicate differences in control of attention between species. Washburn and Baker (2006) also concluded from their comparative studies on attention with distracters that monkeys have a lower level of self generated control on attention than humans do. Percentage of available time spent looking does not show as clear a species difference as does mean duration of looks. Due to the naturalistic setting of the study, the models of the three test species spent different amounts of time with searching, manipulating and feeding. Thus, there might also be some confounding variables in the percentage of looking time. For example, the keas may score highly for watching the searching model because it did not take the model long to find the canister. When the model was searching or manipulating, the kea's mean duration of looks was in the same range as the ones of dogs and marmosets (Range and Huber 2007) and well below the range of children. Finally, the data of the two non-human species tested in this study (keas and dogs) are surprisingly similar to the data on marmosets (Range and Huber 2007) and ravens (Scheid et al. 2007), with some exceptions that might be not entirely related to social attention but lack of inhibition to orient to food-related cues (the case of keas watching a conspecifics feed). This similarity across species might be related to common mechanism in working memory. Nevertheless, the found similarity might also be an artifact of the species studied so far; jackdaws, for example, were much less inclined to watch conspecifics than ravens (Scheid et al. 2007) and showed more variation in the attention getting than the

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attention-holding processes. Further studies, comparing more species, might elucidate other factors that influence attention.

In conclusion, this first comparative study on attention level among species revealed that compared to the non-human species, children showed much longer looks than non-human subjects did. One possible explanation for this difference may be the attention system of a higher level of control that is not acquired to a similar degree in the non-human species investigated here. However, further studies need to investigate this hypothesis in more detail.

The generally short duration of looks of observers in non-human animals indicate that animals are unlikely to grab information about complex sequences of behaviour and their motor pattern. Instantaneous behaviour, information about locality and type of object, results generated in the environment and affordances of objects are more likely to be grabbed in short time by non-human species. Interestingly, despite a similar set-up of the studies, the factors that influenced attention within species varied dramatically, suggesting that it might be worth while to test which factors are important for a particular species, before testing them in social set-ups.

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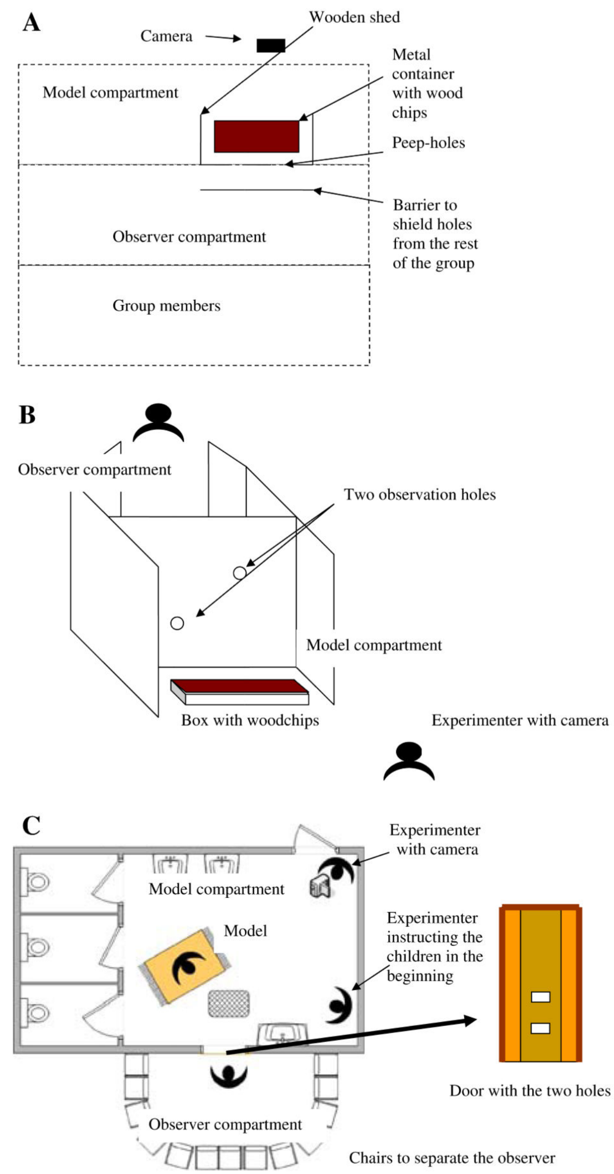

Fig. 1.

Experimental set-up for the kea (**a**), dog (**b**) and children (**c**) experiments

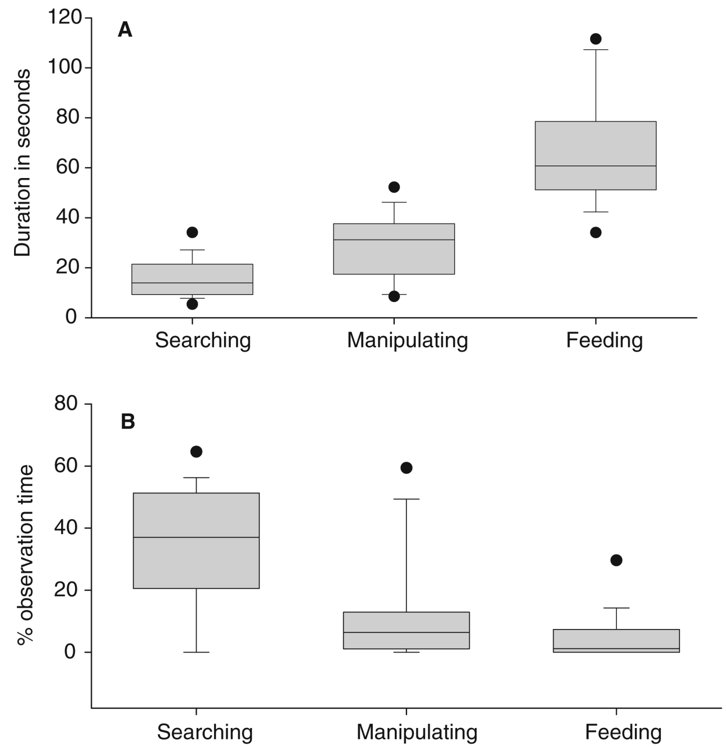

Fig. 2.

Box plots showing the duration of searching, manipulation and feeding by the dog model (**a**) and the percentage of observation time that the dog observers watched the model while it was engaged in these food-directed behaviours (**b**). Shaded boxes represent the interquartile range, bars within shaded boxes are median values and whiskers indicate the 5th and 95th percentile

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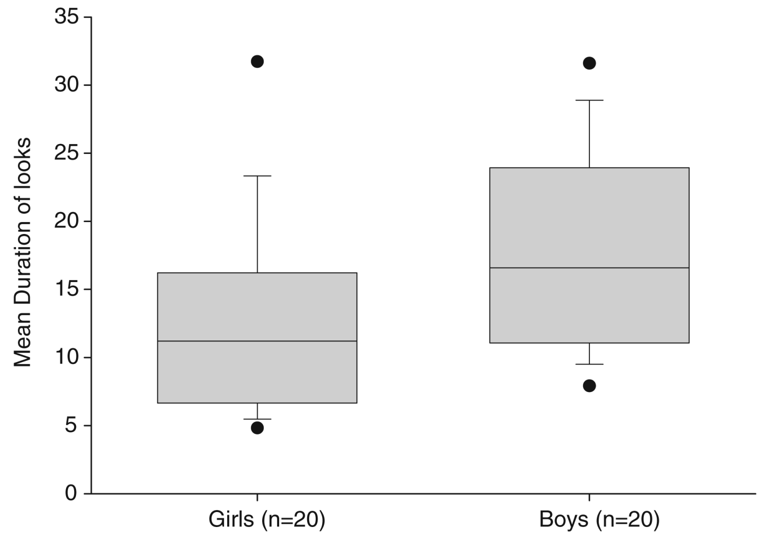

Fig. 3.
Box plots showing the difference in the mean duration of looks between the girls and boys when watching a model. *Shaded boxes* represent the interquartile range, *bars* within *shaded boxes* are median values and *whiskers* indicate the 5th and 95th percentile

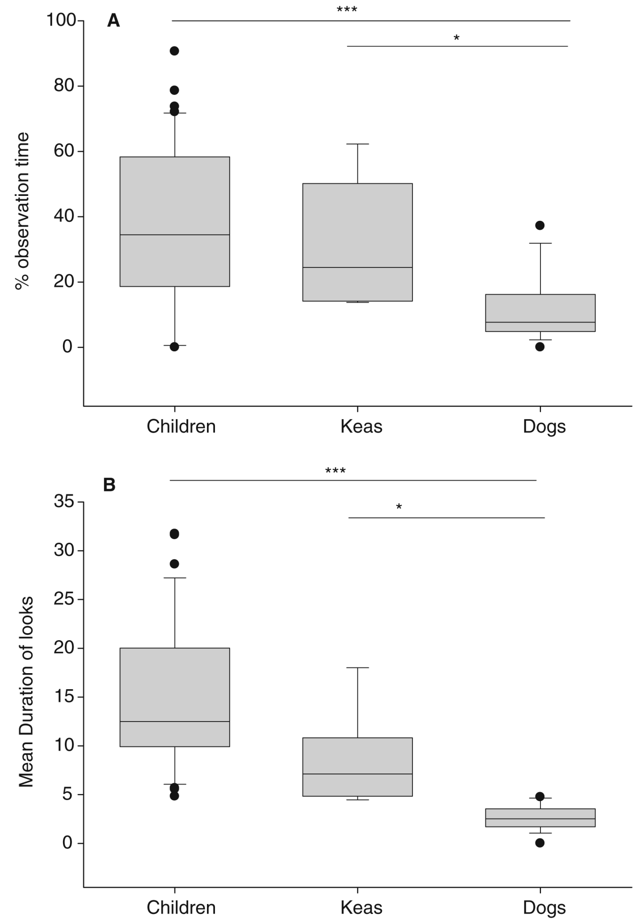

Fig. 4.

Box plots showing differences in the percentage of observation time (**a**) and the mean duration of looks (**b**) of observers watching a conspecific model across three different species tested in the same experimental paradigm. *Shaded boxes* represent the interquartile range, *bars* within *shaded boxes* are median values and *whiskers* indicate the 5th and 95th percentile. *Lines* above the *bars* indicate significant differences between treatments. $*p < 0.5$; $**p < 0.01$, $***p < 0.001$

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Table 1

Median (quartile 1; quartile 3) of observation parameters during diVerent activities of the model

Observer model (duration in seconds)	% observation time	Frequency of looks (per second)	Mean duration of looks (in seconds)
Keas			
Searching [17.14 (16.0; 28.75)]	30.25 (18.0; 38.88)	0.06 (0.03; 0.07)	2.98 (2.60; 4.21)
Manipulating [14.13 (10.10; 16.41)]	34.75 (21.5; 52.06)	0.07 (0.06; 0.10)	2.96 (2.02; 5.82)
Feeding [105.98 (91.8; 121.01)]	33.12 (13.07; 48.04)	0.03 (0.01; 0.04)	10.64 (9.56; 11.93)
Dogs			
Human demonstrator			
Searching [36.47 (34.76; 38.6)]	22.13 (12.7; 33.67)	0.07 (0.04; 0.1)	3.20 (2.7; 3.89)
Manipulating [35.98 (34.32; 38.07)]	18.50 (9.79; 26.21)	0.04 (0.02; 0.06)	3.97 (2.72; 8.19)
Feeding [38.7 (36.56; 40.69)]	12.62 (6.93; 42.1)	0.03 (0.02; 0.05)	5.26 (3.45; 7.32)
Dog demonstrator			
Searching [13.94 (9.39; 20.68)]	37.02 (22.95; 50.61)	0.10 (0.07; 0.18)	2.49 (1.92; 4.7)
Manipulating [31.19 (19.23; 35.91)]	6.41 (1.82; 11.82)	0.04 (0.02; 0.07)	1.91 (1.18; 2.68)
Feeding [60.71 (51.53; 75.45]	1.17 (0; 6.83)	0.01 (0; 0.02)	2.79 (2.03; 3.75)
Children			
Searching [40.7 (22.97; 60.7)]	34.11 (12.97; 63.41)	1.00 (0.67; 1.13)	14.63 (8.13; 24.2)
Manipulating [28.75 (21.8; 42.6)]	34.99 (20.70; 60.18)	0.60 (0.3; 1)	15.19 (10.89; 17.41)
Feeding [15.36 (9.2; 18.1)]	33.33 (14.24; 58.97)	0.60 (0.3; 1)	10.67 (6.67; 14.9)

[a] Food-directed behaviour of the model combines searching, manipulating and feeding

[b] Note that there was no significant difference in the amount of time the model was engaged in other behaviour and food-directed behaviour. In parentheses we present the median duration of the activities

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Table 2

Summary of factors that influences attention in the different species

		Keas	Dogs	Children
Model activity	Searching		+	+
	Manipulating			+
	Eating	+		
Model	Age	+	not tested	
	Sex	not tested		+
	Identity	(+)	(+)	+++