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ORIGINAL PAPER

Dogs can discriminate human smiling faces from blank expressions

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Abstract Dogs have a unique ability to understand visual cues from humans. We investigated whether dogs can discriminate between human facial expressions. Photographs of human faces were used to test nine pet dogs in two-choice discrimination tasks. The training phases involved each dog learning to discriminate between a set of photographs of their owner's smiling and blank face. Of the nine dogs, five fulfilled these criteria and were selected for test sessions. In the test phase, 10 sets of photographs of the owner's smiling and blank face, which had previously not been seen by the dog, were presented. The dogs selected the owner's smiling face significantly more often than expected by chance. In subsequent tests, 10 sets of smiling and blank face photographs of 20 persons unfamiliar to the dogs were presented (10 males and 10 females). There was no statistical difference between the accuracy in the case of the owners and that in the case of unfamiliar persons with the same gender as the owner. However, the accuracy was significantly lower in the case of unfamiliar persons of the opposite gender to that of the owner, than with the owners themselves. These results suggest that dogs can learn to discriminate human smiling faces from blank faces by looking at photographs. Although it remains unclear whether dogs have human-like systems for visual processing of human facial expressions, the ability to learn to discriminate human facial expressions may have helped dogs adapt to human society.

Keywords Dog · Human facial expression · Two-choice discrimination tasks · Visual discrimination

Introduction

Knowing the state of others' emotions is extremely important for social animals to decide their subsequent behaviors and it therefore affects survival. There are many sensory cues for the assessment of others' emotions, and the type of cue that is important varies with species. For humans, facial expressions—extremely complicated visual cues—play a vital role. It is possible to live in harmony with other members of society by reading their emotions from facial expressions and adjusting one's behaviors accordingly (Ekman and Friesen 1975). Dogs (*Canis familiaris*) are also very social animals; they have many visual communication methods in common with wolves (*Canis lupus*), including postures and facial expressions, which indicate dominance status, aggression, and fear (Abrantes 1987; Bradshaw and Nott 1995). In recent years, scientists have begun to focus on social visual cognitive abilities in dogs' interactions with humans. For example, if a human throws a ball for a dog to fetch and then turns his back, the dog almost always brings the ball back around the human's body in order to drop it in front of his face (Hare et al. 1998; Gacsi et al. 2004). Dogs can also understand the relationship between the direction in which humans are facing or gazing and their attentional state (Call et al. 2003; Viranyi et al. 2004; Schwab and Huber 2006). Regarding a dog's individual recognition of humans, recent behavioral studies have shown that dogs generate their internal

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representation of the owner's face when they hear the owner calling them (Adachi et al. 2007), and in visual paired-comparison tasks dogs looked at the pictures of novel human faces longer than at familiar human faces who was not dog's owner (Racca et al. 2010). These studies show that dogs have a fair understanding of human faces and the role that they play in social interaction. Although it remains unclear whether dogs can interpret human emotions by looking at their faces, it will be valuable to clarify whether they can discriminate human facial expressions.

In Japanese monkeys (*Macaca fuscata*), the study of the recognition of facial expressions of humans suggests that it is more difficult for Japanese monkeys to detect the movement of eyebrows in the human face; they do not use this feature for intraspecies communication (Kanazawa 1996). Considering that monkeys unable to discriminate human expressions not used in their interspecies communication in nature, we can predict that it will be difficult for dogs to discriminate human facial expressions, as their facial structure differs greatly from ours. On the other hand, dogs come into contact daily and more closely with humans than do monkeys, and they generally act appropriately according to the different human behavioral cues (Vas et al. 2005). Therefore, dogs may learn to associate human expression with a specific outcome, and they may be able to recognize the movements of human facial parts. To determine whether dogs can discriminate between human facial expressions and can generalize human facial expressions, we conducted a two-choice discrimination task. Range et al. (2008) used this same task to show the ability of dogs to visually classify natural stimuli. We used photographs of smiling human faces as positive stimuli in this study because of the finding that dogs looked at their owners' faces longer when the owners felt happy than when they were sad (Morisaki et al. 2009).

Materials and methods

Subjects

The subjects were four Labrador Retrievers and five Standard Poodles. The age of the subjects was 61.67 ± 10.36 months (mean ± SE). Information about the dogs and their owners is shown in Table 1. All dogs were pets owned by university staff and students. The dogs often came to the university with their owners and interacted with a variety of people. They were maintained on a normal diet, which was not changed during the test period. The dogs had undergone basic obedience training and were naïve to the experimental task.

Stimuli

The presentation stimuli were color photographs of human faces. A summary of the stimuli is shown in Table 2.

The training phases

In the first training phase, a set of face (positive stimulus: S+) and back-of-the-head photographs (negative stimulus: S−) of one particular male person, who was a university student and usually had some contact with each dog 2–5 days per week in the university, was presented to all subjects (Fig. 1a). In the second training phase, a set of each owner's smiling face (S+) and a blank face

Table 1 Information on dogs and their owners

Dogs				Owners		
Name	Breed	Sex	Age (months)	Gender	Age	The period of owning (months)
Charley	SP	Neutered	11	Female	40	9
Cuppa	LR	Male	70	Male	29	46
Fleecia	LR	Neutered	74	Female	23	12
Jasmine	SP	Female	11	Male	39	9
Kai	LR	Neutered	71	Male	22	34
Cody	SP	Male	102	Male	39	100
Anita	SP	Spayed	86	Male	39	84
Punch	SP	Neutered	60	Male	37	58
Fook	LR	Neutered	70	Female	39	58

The five dogs above the dash line met the learning criteria in the training phases and proceeded to the test phase

SP standard poodle, *LR* labrador retriever

Table 2 Experimental procedure and presentation stimuli

Phase	Session	Stimulus photograph	Number of trial
First training phase		A set of the front face (S+) and back of the head (S−) of the familiar male (Fig. 1a)	30 trials/session
Second training phase		A set of each owner's smiling face (S+) and blank face (S−; Fig. 1b)	30 trials/session
Test phase	OW session	10 sets of smiling face (S+) and blank face (S−) of each owner (Fig. 1c)	10 trials/session
	UPSG session	10 sets of smiling face (S+) and blank face (S−) of 10 unfamiliar persons of the same gender as the owner (Fig. 1d)	10 trials/session
	UPOG session	10 sets of smiling face (S+) and blank face (S−) of 10 unfamiliar persons of the opposite gender as the owner (Fig. 1d)	10 trials/session
Control phase	PC session (positive control)	A set of the owner's smiling face (S+) and blank face (S−)	10 trials/session
	SS session	A set of same smiling faces of the owner[a]	10 trials/session
	BB session	A set of same blank faces of the owner[a]	10 trials/session
	AB session	A set of angry (S+) and blank face (S−) of the owner (Fig. 1e)	10 trials/session

[a] The positive stimuli were selected randomly

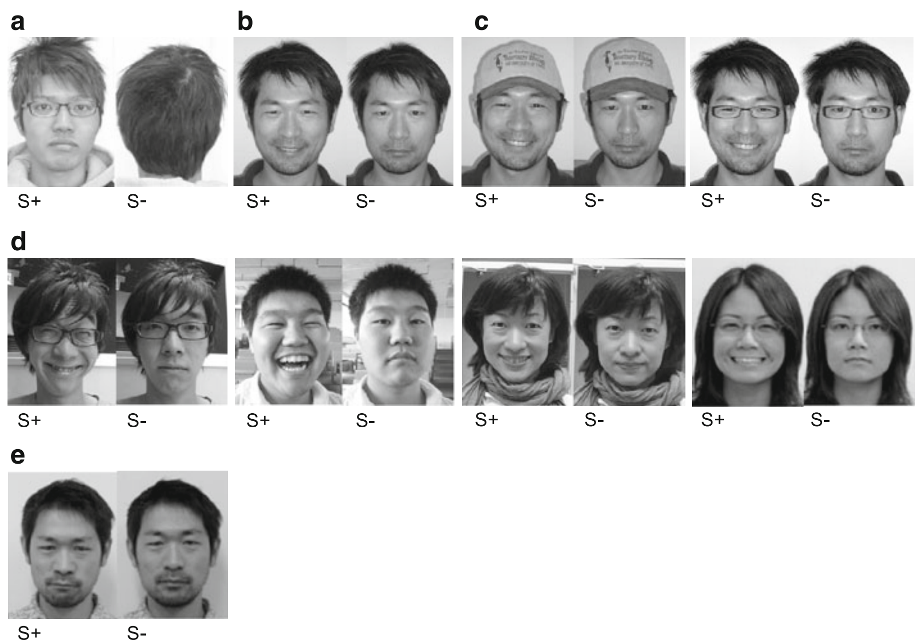

Fig. 1 The stimulus photographs. **a** The same familiar person's face (S+) and back of the head (S−; the first training phase) **b** The owner's smiling (S+) and blank (S−) face (the second training phase) **c** The owner's smiling (S+) and blank (S−) face (OW session in the test phase) **d** The unfamiliar person's smiling (S+) and blank face (S−; UPSG and UPOG sessions in the test phase) **e** The owner's angry face (S+) and blank face (S−; AB session in the control phase)

photographs (S−) was presented (Fig. 1b). All owners were photographed under the same conditions.

The test phase

This phase comprised three kinds of session. In the first session, 10 sets of the smiling face (S+) and blank face (S−) photographs of each owner were presented (OW session). These particular photographs were new to the subject; the owners changed clothes and wore glasses or hats for each photograph (Fig. 1c). In the second session, 10 sets of smiling face (S+) and blank face (S−) photographs of 10 unfamiliar persons of the same gender as the owner were presented (a set of photographs per unfamiliar person, UPSG session; Fig. 1d). In the last session, 10 sets of smiling face (S+) and blank face (S−) photographs of 10 unfamiliar persons of the opposite gender to that of the owner were presented (UPOG session; Fig. 1d). These unfamiliar persons were university students who had never met the subject dogs, and they were photographed at various places.

The control phase

This phase was composed of four sessions. In the first session, a set of smiling (S+) and blank face (S−) photographs of each owner was presented as a positive control (PC session). In the second session, the same smiling faces of the owner were presented simultaneously (SS session), and in the third session, the same blank faces of the owner were presented (BB session). In these sessions, the S+ was chosen randomly. In the final session, photographs of the owner's angry (S+) and blank (S−) face were presented (AB session, Fig. 1e).

Apparatus

The experiments were conducted in a room (4.7 × 4.0 m) at Azabu University, which was familiar to the subject dogs. Two A4 clear PVC folders were attached to the wall at the height of each dog's head (about 0.3–0.5 m above the ground). The distance between the two folders was 0.1 m. The stimuli were presented as A4 photographs inside these folders in order to prevent dogs from getting olfactory cues. Before presentation of the stimuli, the experimenter made the dogs sit and wait at the waiting position 1 m away from the wall. The dogs were not on a leash during the experiments. In order to prevent the dogs from observing the exchange of stimulus photographs, the partition (0.8 × 1.2 m) was set between the dogs and wall, and it was removed after the exchange of stimulus photographs. In order to control possible social cues when dogs selected the photographs, the experimenter stood 1.5 m behind the dogs and then cued them to select photographs (Fig. 2). When dogs selected S+ photographs, they were rewarded with commercial dog treats.

Procedure

First, the dogs were trained to touch the experimenter's hand with their nose at a cue, through a shaping procedure in which operant conditioning, using positive reinforcement (food reward) and negative punishment (longer interval), was conducted. If the dogs did touch the experimenter's hand with their noses, treats were given to them at the sound of a clicker, and if dogs did something else, they were commanded to sit and stay for 20 s. The dogs were then trained to touch the photograph of the experimenter's hand in the clear folder on the wall. After the dogs were accustomed to touching the clear folder with their noses, they were allowed to proceed to the first training phase. The procedure of experiments is shown in Table 2.

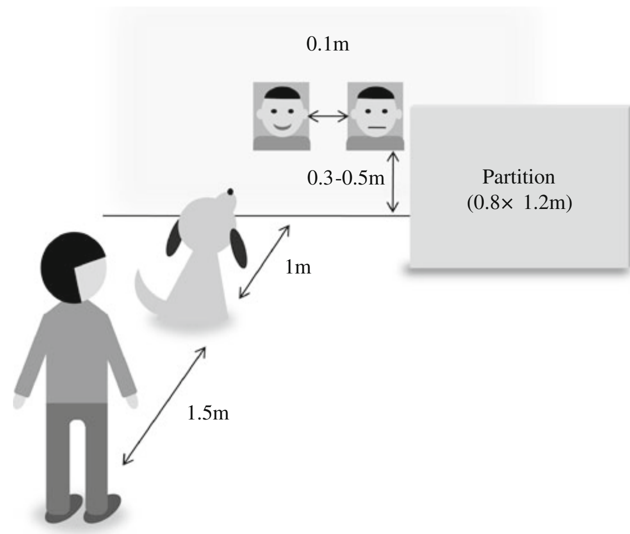

Fig. 2 The experimental design. The photographs were placed in 2 PVC folders attached to the wall, side-by-side, 10 cm apart. The experimenter made the dog sit 1 m away from the wall and then moved 1.5 m behind the dog before cueing it to select photographs

The first training phase

One positive (the front face of a familiar person) and one negative (the back of the head of the same person) training stimuli were presented simultaneously. Two stimulus photographs were placed in the clear folders on the wall, and their positions were changed randomly once in each trial. Each session consisted of 30 trials. If dogs touch the S+ directly, a reward was provided immediately, accompanied by a "click" sound. If dogs touched the S−, the experimenter made the dog sit and stay for 20 s and then a correction trial was conducted. In a correction trial, once the stimulus photographs were hidden by the partition, we again presented them in identical positions as before. Until dogs touch the S+, trials were repeated with photographs in identical positions. The dogs were transferred to the second training phase after they reliably performed on a level at or beyond the learning criteria. The criterion of the first training phase required ≥21 correct first choices in 30 trials in three consecutive sessions.

The second training phase

A set of photographs of the owner's face—one smiling face (S+) and one blank face (S−)—was used repeatedly as the discrimination stimulus. The procedure was the same as for the first training phase. The learning criterion of the second training phase required ≥24 correct first choices in 30 trials over four consecutive sessions. The dogs that achieved this proceeded to the test phase. Each session of both training phases included a 10-min break. A session lasted approximately 10–15 min, and 2–4 sessions were conducted in 1 day, depending on the state of the dogs. Sessions were conducted 2 or 3 days in a week.

The test phase

The test phase comprised three kinds of session. To examine whether the dog could discriminate the various photographs of the smiling face of the owner, we presented the 10 sets of smiling and blank faces of the owner (OW session). The OW session consisted of 10 trials, and the same photographs were not presented again. Then, whether the dog could discriminate the smiling faces of unfamiliar persons was tested (UPSG session and UPOG session). These sessions also consisted of 10 trials. First, the OW session was conducted, then the UPSG, and UPOG sessions. These procedures were the same as those of the training phases except for the number of trials, and the correction trials were not conducted. A session took approximately 5 min, and one session was conducted per day.

The control phase

The control phase was conducted in order to verify that: (1) the experimenter did not provide cues to the subjects unawarely and (2) the dogs did not learn to choose the photograph of "not a blank face." The control phase consisted of four kinds of session. The procedure for all sessions was the same as for the test session, and each session consisted of 10 trials. The first session was a positive control session (PC session: smiling (S+) and blank face (S−) of owner). Next, for purpose (1), an SS session (the same smiling faces were presented simultaneously) was conducted, followed by a BB session (the same blank faces were presented). The S+ in the SS and BB sessions was decided randomly. If dogs selected S+ beyond chance level even though there were no visually correct stimuli, they might understand the experimenter's unconscious cues to select S+. The last session was an AB session, in which the owner's angry (S+) and blank face (S−) were presented for purpose (2). If dogs selected angry faces beyond the chance level, it meant that they might not have selected S+ by using the image of the smiling expression during the test phase. A session took approximately 5–7 min, and one session was conducted in 1 day.

Statistics

In the test phase and the control phase, the comparisons of the correct response rate of all dogs and the chance level in each session were analyzed by a binomial test. The differences between the medians of response rates of sessions per phase were analyzed by a Kruskal–Wallis test, and if significant differences were shown, a Mann–Whitney U test was used for the post hoc analysis. In the post hoc analysis, the significance level of 1.67%, in the case of the comparison of three sessions, and the significance level 0.8%, in the case of the comparison of four sessions, are equivalent to 5% (Bonferroni correction; SPSS v.17.0). Results were expressed as medians (interquartile range). The ages and number of trials in the training phases of dogs were expressed as mean ± SE.

Results

In the first training phase, five of the nine dogs (four males and one female, 47.4 ± 14.9 months old) met the learning criterion. The mean of trials needed to meet the criterion was 4.6 ± 0.5 trials (Fig. 3a). The other four dogs showed an extremely strong lateral bias when selecting stimuli. Three dogs (Cody, Punch, and Fook) selected the left photograph with above 90% (27/30 trial) at the first five sessions. Therefore, we judged that these dogs did not meet the criteria in the first training phase. A fourth dog (Anita) often selected the right photograph but eventually stopped selecting the stimuli. Thus, they did not pass the first training phase.

In the second training phase, all five dogs met the criterion; however, the oldest dog (Fleecia) needed 2–3 times more trials (41 trials) than did the other dogs (12, 14, 19 trials; Fig. 3b). The mean number of trials needed to meet the criterion was 20.0 ± 5.4 trials. With the small sample size used in this study, it was not possible to determine whether these differences were due to sex, age, breed, or to individual characteristics.

In the test phase, the correct response rates in the OW session and in the UPSG session were significantly higher than the chance level by a binomial test (OW: 80(80–85)%, $P < 0.001$, UPSG: 80(70–85)%, $P < 0.001$). In the UPOG session, the correct response rate was 70(50–70)% and there was no significant difference with the chance level ($P = 0.12$; Fig. 4a). As a result of the Kruskal–Wallis test to compare the correct response rates of three sessions, a significant difference was detected among three sessions: $\chi^2(2) = 8.76$, $P = 0.01$, and the median correct response rate in the OW session was significantly higher than that in the UPOG session ($Z = -2.74$, $P = 0.006$; Fig. 4b). There was no statistical difference between the median correct response rate in the OW and in the UPSG session, and between the UPSG and UPOG sessions (OW-UPSG: $Z = -0.95$, $P = 0.34$; UPSG-UPOG: $Z = -2.13$, $P = 0.03$).

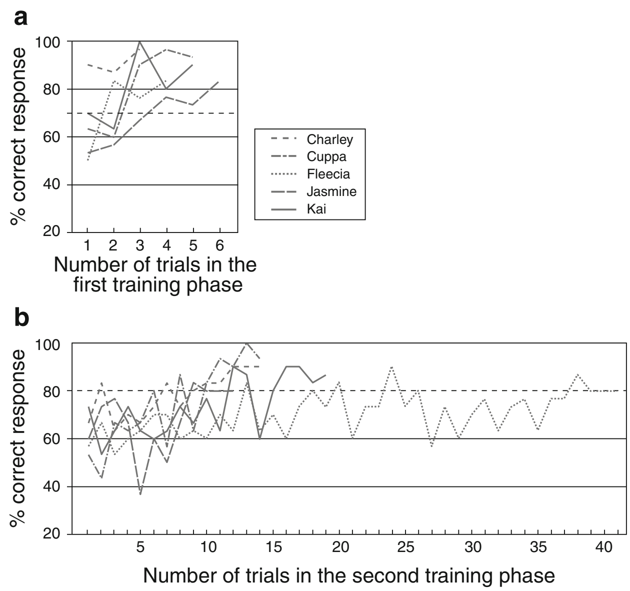

Fig. 3 The correct response rates in the training phases. **a** The criterion for successfully completing the first training phase was ≥21 correct first choices in 30 trials in three consecutive sessions. **b** The criterion for successfully completing the second training phase was ≥24 correct first choices in 30 trials in four consecutive sessions

In the control phase, the correct response rate in all dogs in the PC session was 80(80–100)% and it was significantly higher than the chance level, using the binominal test ($P < 0.001$). There were no significant differences between the correct response rates in other sessions and the chance level (SS: 60(40–60)%, $P = 0.89$; BB: 50(35–60)%, $P = 0.89$; AB: 30(25–55)%, $P = 0.12$; Fig. 5a). The Kruskal–Wallis test showed that there was a significant difference among the medians of the correct response rate of four sessions ($\chi^2(3) = 12.08$, $P = 0.007$). The median correct response rate in the PC session was significantly higher than that in other sessions (PC vs. SS: $Z = 2.69$, $P = 0.007$; PC vs. BB: $Z = -2.66$, $P < 0.008$; PC vs. AB: $Z = -2.66$, $P < 0.008$); however, other comparison showed no significant differences (Fig. 5b).

Discussion

We conducted a 2-choice task to determine whether dogs could learn to discriminate between a smiling and a blank human face and generalize the smiling expression. In the first training phase, four of the nine dogs were rejected because of strong lateral bias. Dogs usually show lateralized behavior (Wells 2003), and dogs demonstrated a natural gaze bias toward the left visual field like adult humans when looking at human faces (Guo et al. 2009). In future study, using a two-choice task, the issue of lateral bias will need to be addressed. All the rest five dogs met the learning criteria of the first training phase and the second training phase and proceeded to the test phase.

In the test phase, all five dogs were able, significantly more often than expected by chance, to discriminate their owners' smiling faces from their blank faces. When shown photographs of unfamiliar persons, they were also able to significantly more often discriminate smiling faces from blank faces of unfamiliar persons of the same gender as their owners than the chance level. However, their correct response rate in cases of unfamiliar persons of the opposite gender to their owners did not differ significantly from the chance level, and it was significantly lower than in the case of their owners. Although almost half of the dogs were

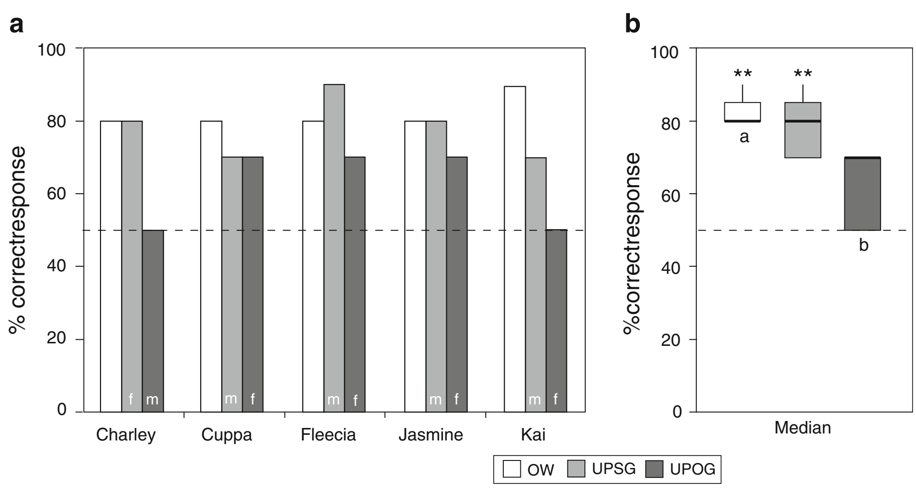

Fig. 4 The correct response rate in the test phase. **a** In the OW session, the correct response rate in all dogs was ≥80%; however, in the UPOG session, the correct response rate tended to decrease ("m" in *bars* means an unfamiliar male; "f" means an unfamiliar female). **b** Only the correct response rate in the UPOG session was not beyond the chance level and was significantly lower than that in OW session. $^{**}P < 0.001$ (vs. chance level; binomial test) **a–b** $P = 0.006$ Kruskal–Wallis test, Mann–Whitney *U* test (Bonferroni correction)

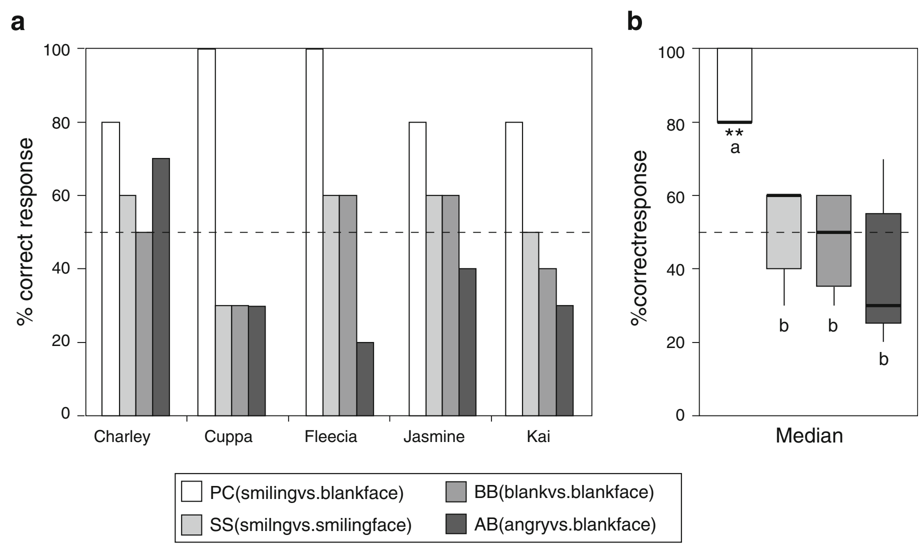

Fig. 5 The correct response rate in the control phase. **a** The correct response rates showed declining trends except for the PC session. **b** Only the PC session was significantly beyond the chance level. $^{**}P < 0.001$ (vs. chance level; binomial test) **a**–**b** $P < 0.008$ Kruskal–Wallis test, Mann–Whitney U test (Bonferroni correction)

rejected during the selection procedure and the test sample was small, these results suggest that dogs can learn to discriminate between smiling and blank human faces conditionally.

In this study, we must consider the difference in the correct response rate depending on the unfamiliar person's gender. The dogs in this study were normal house dogs and lived with the owner and a family member, except in the cases of two dogs whose owners lived alone. These two dogs also had sufficient daily contact with humans of both genders. Therefore, it is not reasonable to assume that these dogs were unfamiliar with persons of the opposite gender to their owner. It was shown that dogs behave toward humans in a gender-dependent manner in case of the presentation of the human whole body (Lore and Eisenberg 1986) and have the concept of gender on the monitor (Takaoka et al. 2009). Probably, some subtle differences in the structure of the face between males and females may pose an impediment (Cellerino et al. 2004), and it may have been somewhat difficult for dogs to understand the smiling face as a common feature in males and females. One possible explanation was that the relationship with the particular owner resulted in gender-dependent generalization by dogs. Dogs can form extremely affiliative relationships with humans, and it is possible for dogs and humans to establish the kind of bond seen between members of the same species (Nagasawa et al. 2009). Therefore, dogs place the greatest focus on information gained from their owner, with whom they have the most interaction on a day-to-day basis, and they might perform more poorly at the discrimination task involving an unfamiliar person of the opposite gender to their owner.

Unfortunately, it was difficult to clarify the generalization of human facial expression by dogs because of small sample in the present study. It has been shown that dogs are able to categorize acoustic and visual stimuli (Heffner 1975; Range et al. 2008), and it has been suggested that they have a concept of human gender (Takaoka et al. 2009). Therefore, the ability of dogs in generalization of human facial expression may be able to be proven by sample addition. Additionally, in the present study, we tested only two breeds. Wobber et al. (2009) suggested that dog's human-like social skills differed among breeds; it has yet to be verified whether there are breed-dependent differences in the ability to discriminate between human facial expressions.

In the control phase, the correct response rates of the sessions showing the same expressions simultaneously (smiling face and smiling face in the SS session and blank face and blank face in the BB session), and these rates were significantly lower than those of the positive control sessions. These sessions were conducted in order to exclude the influence of the experimenter's unaware cues to the dogs to select the correct stimuli, and dogs could not select the S+ because there were no visually correct stimuli. Although we cannot exclude a possibility that the experimenter's unaware behavior in these sessions, these control sessions suggested that the dogs used only the stimuli presented to them, not unaware cues from the experimenter, to select the S+ in the test phase. In order to exclude the influence from the experimenter, the more appropriate apparatus, such as a monitor with a touch-sensitive switch and automatic feeder, is needed for future studies. In the session using owners' angry and blank faces (AB session), with the angry face serving as the S+ in the control phase, there was no significant difference from chance. This shows that during the training phases, the dogs had not learned to avoid selecting a blank face but had learned to select a smiling face.

Now, we have to also focus on the poor performance of the dogs in the second training phase (training to discriminate between the smiling (S+) and blank face (S−). Dogs are extremely sensitive to human behavior, and they can acquire associative learning by taking cues from the subtle movements of humans (Udell et al. 2010). However, the second training phase (owner's smiling face vs. blank face) necessitated more sessions in order to meet the criterion than did the first training phase (the familiar male's face vs. the back of the head). This may have been solely due to the difference in the size of the targets used for discrimination. However, another possible explanation is that it is fundamentally difficult for dogs to recognize human facial expressions.

Kanazawa (1996) found that Japanese monkeys could discriminate human "happiness" faces but could not discriminate between human "anger/disgust" and "sad" faces. Kanazawa deduces that as human smiles resemble the grimace that shows submission in monkeys, the monkeys may have used this grimace to discriminate the "happiness" face. Dogs and humans are located much further away on the "evolutionary tree" than are monkeys and humans, and the structure of a dog's face differs greatly from ours. Yet, canines also use facial expressions, such as the movement of mouth, ears, and eye area (Fox 1970), in their communication, and they have lived closely with humans. Therefore, dogs might alternatively be able to recognize movement in human facial components. However, the fact that the five could discriminate between smiling and blank faces in the test phase might largely be attributable to the obvious differences in the facial features, for example, whether teeth were visible in the smiling condition. There have been different suggestions regarding dog's cognition of human faces: Guo et al. (2009) suggested that dogs may use a human-like gaze strategy for the processing of human facial information, while Racca et al. (2010) showed the possibility that the techniques dogs use for the visual processing of facial stimuli are different than those humans or other primates use. Further studies are needed to determine which facial parts are involved, how visually processing dogs discriminate human facial expressions, and whether dogs really do categorize expressions.

Other possible reason is that the stimuli in this experiment were two-dimensional photographs and were contextually insufficient; that is, perhaps they did not recognize the images in the photographs as human faces. Therefore, because we thought that the presentation of the stimuli by two-dimensional photographs did not arouse the dog's aversive behavior, the owner's angry face photographs were employed as the stimuli in the control phase. As a result, the correct response rate in the AB session—angry face (S+) versus blank face (S−)—was not higher than chance level. In previous studies that used three-dimensional and whole human bodies as stimuli, dogs showed the coordinated reaction without training (Vas et al. 2005; Morisaki et al. 2009). So the presentation of visual stimuli to dogs requires more consideration in future studies.

The present study indicates that dogs undergo a learning process under the experimental condition, which enables them to discriminate human smiling faces from blank faces. Among humans, the ability to accurately recognize other people's expressions and judge their emotions is a vital social skill. This study has shown that dogs that live closely with humans are also able to recognize positive facial expressions, indicating that these dogs have acquired the social skills helpful to survive. The ability to learn to discriminate human facial expressions must have helped dogs to adapt to human society.

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