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SHORT COMMUNICATION

# Can domestic dogs (*Canis familiaris*) use referential emotional expressions to locate hidden food?

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**Abstract** Although many studies have investigated domestic dogs' (*Canis familiaris*) use of human communicative cues, little is known about their use of humans' emotional expressions. We conducted a study following the general paradigm of Repacholi in Dev Psychol 34:1017–1025, (1998) and tested four breeds of dogs in the laboratory and another breed in the open air. In our study, a human reacted emotionally (happy, neutral or disgust) to the hidden contents of two boxes, after which the dog was then allowed to choose one of the boxes. Dogs tested in the laboratory distinguished between the most distinct of the expressed emotions (Happy–Disgust condition) by choosing appropriately, but performed at chance level when the two emotions were less distinct (Happy–Neutral condition). The breed tested in the open air passed both conditions, but this breed's differing testing setup might have been responsible for their success. Although without meaningful emotional expressions, when given a choice, these subjects chose randomly, their performance did not differ from that in the experimental conditions. Based on the findings revealed in the laboratory, we suggest that some domestic dogs recognize both the directedness and the valence of some human emotional expressions.

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## Introduction

Domestic dogs (*Canis familiaris*) use a variety of experimenter-given cues to locate hidden food. For instance, in the object-choice paradigm an experimenter hides food under one of several distinct cups out of the dog's view and then gives a cue to indicate the cup which contains the food. The dog is then allowed to choose a cup and retrieves its content. The most prominent of cues given in such situations are communicative cues like pointing or head orientation, which are often accompanied by gaze alternation between the subject and the target object to reinforce the communicative nature of the action. Dogs can use such communicative cues successfully without any training (Hare et al. 1998, 2002; Miklósi et al. 1998; Hare and Tomasello 1999; Soproni et al. 2001, 2002; see Miklósi and Soproni 2006 for a review). Moreover, dogs can also use more indirect communicative signals to find hidden food: when they observe a human placing an object (marker) on the baited cup they select this cup (Agnetta et al. 2000; Riedel et al. 2005 but see, Udell et al. 2008a, b for a challenge to this result). In several studies, it has been shown that the dogs' success when presented with object-choice paradigms and the cues mentioned truly relies on their use of these cues and cannot be explained alternatively by a use of pure local enhancement or odor as a cue to find the food (Hare and Tomasello 1999; Szetei et al. 2003; McKinley and Sambrook 2000).

An interesting question is whether dogs have to learn those cues during their ontogeny or whether domestication equipped them with the ability to use such cues. Although dogs diverged from wild wolves (*Canis lupus*) very recently in evolutionary terms, they outperform their closest relatives in using human communicative cues (Agnetta et al. 2000; Hare et al. 2002). Riedel et al. (2008) further demonstrated that even dog puppies at the age of six weeks readily use a variety of communicative cues such as pointing or the placement of a marker. This underlines the assumption that dogs do not have to learn those cues during their ontogeny but that they have a predisposition to respond to such cues (Hare and Tomasello 2005; Hare et al. 2010; but see Dorey et al. 2010; Udell et al. 2010; Udell and Wynne 2010 for the idea that dogs learn to use such cues mainly during ontogeny).

To investigate the effects of domestication more intensely, it is also important to compare different breeds of dogs in their use of human communicative cues. McKinley and Sambrook (2000) found evidence for an impact of training on dogs' social cognition by showing that trained gundogs outperformed non-trained gundogs in comprehension of the pointing gesture. Additionally, there were no differences found between non-trained gundogs and non-trained non-gundogs. The authors concluded that dogs' use of humans' pointing and gazing cues depends "[…] on cognitive ability, the evolutionary consequences of domestication and enculturation by humans within the individual's lifetime" (McKinley and Sambrook 2000). Further, Wobber et al. (2009) categorized domestic dog breeds according to whether they have been selected to work with humans. When presented with gaze and point cues, the group of working dogs (Huskies, Retrievers and Shepherds) outperformed the group of non-working dogs (basenjis and toy dogs). On the basis of their results, the authors concluded that a specific trait selection could affect dogs' skills in understanding humans' communicative signals, which follows McKinley and Sambrook (2000) domestication argument.

There is one kind of cue whose comprehension has rarely been investigated in domestic dogs: emotional expressions. For humans, emotional expressions play an important role in everyday life. Early in ontogeny, by four months of age, human infants already discriminate between some facial expressions such as fear and happiness (Nelson 1987). Although domestic dogs share their everyday life with humans, there is only one study that has presented this species with different human emotions to investigate the role of emotional emphasis when a command is given. For that purpose, Mills et al. (2005) trained ten pet dogs to reliably respond to two neutrally given commands ("Sit" and "Come"). At test, these commands were then given varying in their emotional content (e.g., neutral, happy, gloomy or angry), and latency between giving the command and the dogs' response was measured. The authors found no evidence that dogs responded consistently differently to commands given with different emotional content. Unfortunately, the design of this study sheds little light on domestic dogs' understanding of human emotional expressions as referential, that is, as having an external entity they are directed at, and therefore as helpful indicators to aid when making decisions.

The aim of our study was to address this issue. We modified a paradigm used with human infants and tested five breeds of working dogs (Huskies, Labrador and Golden Retrievers, Border Collies and German Shepherds). Since no previous study had investigated dogs' referential use of human emotional cues, we were not able to make clear predictions whether or not dogs would perform successfully.

Our study was based on that of Repacholi (1998) In this study, 14-month-old infants saw an adult approaches two boxes, open each one in turn, and show an emotional expression according to the content of each box (either happiness or disgust). When handed both boxes afterward, the infants were more likely to open the box to which the adult had responded with a happy expression. This preference indicated that the infants used both the directedness and the valence of the emotional signals. In our study, we asked whether domestic dogs would select a box based on an experimenter's emotional reaction to its content. We presented the subjects with two conditions. In the Happy–Neutral condition, one box was baited with desirable food and provoked a happy emotion from the experimenter, while the other box was baited with an inedible object and provoked a neutral reaction from the experimenter. In the Happy–Disgust condition, one box was baited with food as before, but the other box was baited with garlic and provoked a disgusted emotion from the experimenter. Then dogs were allowed to select one of two containers to receive its content (see also Buttelmann et al. (2009) for the use of this setup with great apes). The current study also included a control test for the Huskies to investigate whether they could succeed simply by using olfactory cues since they were the only breed tested outdoors. Control subjects were presented with the same procedure as in the experimental conditions with the crucial difference that the human experimenter always reacted neutrally to the contents of the boxes.

## Methods

### Subjects

Fifty-eight domestic dogs (*C. familiaris*) of five breeds (bred for different purposes such as racing, hunting and herding with different levels of training, and in different housing conditions, see below) participated in the study.

There were 20 Huskies (Siberian Huskies, 6 females, mean age = 4.9 years, SD = 3.85 years), ten Labrador Retrievers (4 females, mean age = 3.9 years, SD = 2.32 years), ten Golden Retrievers (5 females, mean age = 3.4 years, SD = 1.61 years), ten Border Collies (7 females, mean age = 4.3 years, SD = 3.26 years) and eight German Shepherds (4 females, mean age = 5.7 years, SD = 2.25 years). All dogs except the Huskies were recruited by phone from owners in a medium-sized German city where they lived in human families. The Huskies were owned by four different owners but all kept in one facility (5–6 per enclosure) where different people worked with them (for racing). Some dogs had participated in previous experiments, but none of these used emotional expressions. Four additional dogs were dropped from the study due to lack of attention and low food motivation.

## Materials and setup

All breeds except the Huskies were tested in a room of approximately 10 $m^2$, most of them with owners present. The Huskies were tested in the open air in an enclosure belonging to their owners where other Huskies not being tested could be heard (but not seen) by the subjects. For all subjects, an experimenter sat behind a test table (82 × 38 × 41 cm). Two identical opaque plastic boxes (15 × 15 × 15 cm) with lids (thin square plastic pieces, 20 × 20 cm) were placed on the table (one left, one right). The type of object inside each of these boxes varied according to condition. Some pilot dogs had been presented with a preference test involving different kinds of foods and objects to see which dogs liked most, behaved neutral to and tried to avoid. Those foods and objects were then used in our studies, accordingly. Assistant 1 baited the boxes in each trial, and during this time, the subject's view was blocked with a plastic occluder (100 × 50 cm). During testing, assistant 2 or the owner of the dog stood behind the subject and held it by the collar, with its two forelegs on a marked spot 2 m in front of the test table. All tests were videotaped.

## Design

Subjects were tested in two different conditions. In both conditions, the experimenter opened both boxes in succession and reacted with different emotions to their contents. In the Happy–Neutral condition the experimenter reacted to one of the contents with a happy display; the box contained a piece of sausage. He reacted to the other content with a neutral expression; the box contained some pieces of wood shavings. In the Happy–Disgust condition, the experimenter reacted to the box containing a piece of sausage with the same happy expression, but the alternative box contained a piece of garlic and so the experimenter reacted with a disgusted expression. The experimenter's emotional expressions of happiness and disgust were based on the descriptions of Ekman and Friesen (1975), see Fig. 1. For the neutral display, he had his eyes open, mouth closed and all facial muscles relaxed. Happy and disgust facial expressions were accompanied by verbalizations to augment the amount of emotional information available for the subject. However, these additional emotional cues did not have specific content: The experimenter began with a condition-appropriate exclamation ("Oh!" for happy or "Eww!" for disgust) followed by the same German word "Nachtigall" ("nightingale") with a different intonational structure for each of the two emotional expressions. No vocalization was given when he presented a neutral expression.

The side placements of the contents of the boxes as well as the box first opened by the experimenter were counterbalanced. Each subject received 9 trials per condition in each of two test sessions (on the same day, with a 15-min break in between) in a randomized order, so that each subject received a total of 18 trials per condition. Each subject's choice was coded live.

## Procedure

The first test session started with warm-up trials. In these trials, the experimenter removed the lids from the empty boxes and placed them in front of the boxes on his side of the table. As the subject was watching, he then put a dog treat in one of the two boxes and the subject could make a choice. This ensured that subjects knew the boxes could contain food and that they would receive the content of the box they chose. Once a subject chose correctly on 4 out of 5 trials, the warm-up period ended and the test period began. The majority of dogs met this criterion immediately; the fifteen dogs that did not were given additional warm-up trials (the maximum needed was 11 trials for one Border Collie).

To begin each test trial, the experimenter stood up, turned around and looked away pretending to be busy. Once he had turned away, assistant 1 raised the plastic occluder on the table in front of the two boxes so that the subject could not observe the hiding process. She then removed the lids from the boxes (starting with the left one first), placed them in the middle of the table, and baited first the left box and then the right one with the appropriate object (sausage, garlic or wood shavings) according to condition. After this she replaced the lids (starting with the right one) and removed the occluder. At this point, the experimenter returned to the test table, sat down and called the subject's name. Once the subject was attending, he gazed at one box, lifted its lid, such that he but not the


**Fig. 1** The emotional expressions shown by the experimenter: **a** "Happy" when finding a piece of sausage inside the *box*; **b** "Disgusted" when finding garlic inside the *box*; and **c** "Neutral" when finding bedding material inside the *box*. All expressions are pictured as seen by the subjects

subject could see inside the box, and he then looked into the box, giving the appropriate emotional expression. He then looked at the subject for 2 s while saying "Nachtigall" with the appropriate emotional expression. After looking back at the contents of the box for 2 s, he closed the lid and gave the other cue for the remaining box. The displays took the same amount of time for each box. All demonstrations were done with the experimenter's left hand for the left box and his right hand for the right box.

After the experimenter had finished giving the cues, he looked at the middle of the test table and gave a short command ("Okay!") so that assistant 2 (or the owner) released the dog. The subject then indicated one of the boxes by touching it with the nose. When subjects chose the box associated with the "Happy" emotional display, they were given the piece of sausage. If they chose the other box ("Neutral" or "Disgust" depending on condition), they were shown (and could smell) the contents of the box. If subjects were not successful in locating the food for 3 trials in a row they were given a piece of sausage out of a container to keep them motivated. Further, if subjects had shown a clear side bias during their first session, their second session again started with a short warm-up (four consecutive trials) similar to the one at the beginning of the test in which the experimenter obviously baited one box with a piece of sausage and the subjects were given a choice then. This, again, was done to ensure that they knew that both boxes could contain food.

All trials were videotaped, and a second independent person coded 25 % of the choices for reliability. Reliability over both conditions and sessions (36 trials per subject, choice left or right) was perfect (*Cohen's kappa* = 1.00). Because of the small sample sizes of some of the breeds non-parametric statistics were used throughout.

## Results

Overall, subjects as a group chose the box reacted to with a happy expression in 52.1 % of the trials in the Happy–Neutral condition and in 54.9 % of the trials in the Happy–Disgust condition (note that the mean percentages of trials we report here are not directly comparable to the percentage of participants reported in Repacholi's (1998) study). Each dog's performance is displayed in Fig. 2 for the Happy–Neutral condition and in Fig. 3 for the Happy–Disgust condition. Subjects as a group chose the box with food at above chance levels in both conditions: Wilcoxon tests; Happy–Neutral condition: $T^{+}$= 155.50, $N = 32$ (26 ties), $p = .038$, $r = .27$; Happy–Disgust condition: $T^{+}$= 82.50, $N = 36$ (22 ties), $p < .001$, $r = .53$; with a strong trend indicating a difference between conditions: $T^{+}$= 648.50, $N = 44$ (14 ties), $p = .0068$, $r = .24$. Although some subjects performed correctly in more than 70 % of trials (13 out of 18), no subject had individual results that were significantly above chance level (Binominal tests, all $ps \geq .096$).

Since one breed, that is, the Huskies, was tested outdoors and all other breeds were tested indoors, we checked for differences between these two groups. The means for the Happy–Neutral/Happy–Disgust conditions were: Huskies (outdoors) 54.2 %/59.2 %, all other breeds (indoors) 51.0 %/52.6 %, respectively. There was no difference between groups for the Happy–Neutral condition ($U$ (20, 37) = 294.5, $Z = -1.477$, $p = .140$) but for the Happy–Disgust condition ($U$ (20, 37) = 212.5, $Z = -2.842$ $p = .004$, $r = .37$). We therefore analyzed the two groups separately.

The dogs tested indoors did not choose the box reacted to with a happy expression significantly from chance level in the Happy–Neutral condition ($T^{+}$= 80.0, $N = 20$ (18 ties), $p = .335$) but did so in the Happy–Disgust condition

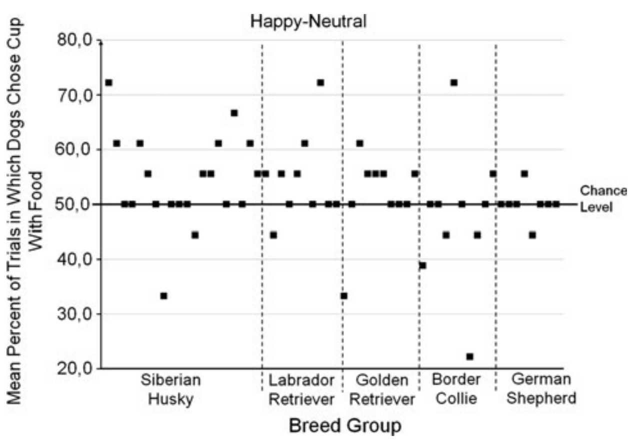


**Fig. 2** Mean percentage of correct choices (food) on an individual level separated by breed in the Happy–Neutral condition

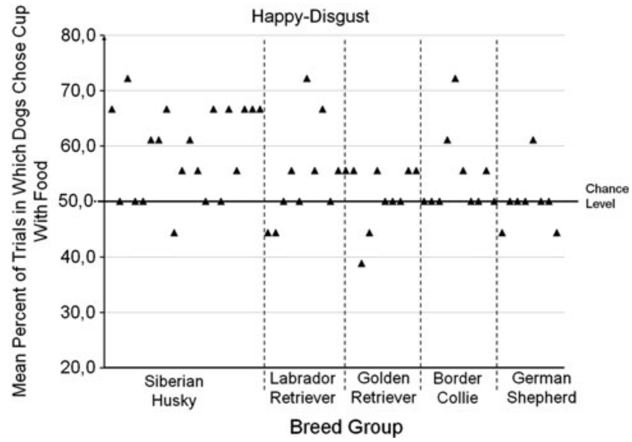


**Fig. 3** Mean percentage of correct choices (food) on an individual level separated by breed in the Happy–Disgust condition

($T^{+}$= 57.0, $N = 21$ (17 ties), $p = .033$, $r = .34$). The mean percentages of correct trials in the Happy–Neutral and the Happy–Disgust conditions for the separate breeds were as follows: Labrador retrievers 54.4 and 54.4 %, Golden retrievers 51.7 and 51.1 %, Border collies 47.8 and 54.4 %, German shepherds 50.0 and 50.0 %, respectively. There were no significant differences between breeds (Kruskal–Wallis tests; all $ps \geq .195$). The performance of the dogs that were tested outdoors differed significantly from chance level in both conditions: Happy–Neutral condition: $T^{+}$= 13.50, $N = 12$ (8 ties), $p = .043$, $r = .45$; Happy–Disgust condition: $T^{+}$= 2.50, $N = 15$ (5 ties), $p = .001$, $r = .74$.

On an individual level, 37 subjects (63.8 %) showed a clear 50 % performance in at least one condition. Out of those 37 subjects, 26 subjects (25 % of the Huskies; 60 % of the Labrador Retrievers; 40 % of the Golden Retrievers; 50 % of the Border Collies; 75 % of the German Shepherds) showed a significant side bias in both conditions (Binominal tests, $p \leq .031$). Six subjects (20 % of the Huskies; 20 % of the Border Collies) showed a significant bias in one condition (4 subjects in Happy–Neutral; 2 subjects in Happy–Disgust; Binominal tests, $p \leq .031$). Five of those 37 subjects (15 % of the Huskies; 10 % of the Golden Retrievers; 13 % of the German Shepherds) showed no side bias in neither of the two conditions. Performance at exactly the chance level of 50 % can be explained by subjects' side biases in both conditions (26 out of 37 subjects; Binominal test, $p = .020$). We also analyzed whether subjects had a preference for the box touched last by the experimenter.[1] If so, their choice of the box touched last by the experimenter should exceed chance level. On a group level, no evidence could be found for this assumption, Wilcoxon test, $T^{+}$= 652.00, $N = 46$ (12 ties),

[1] We are grateful for this suggestion to two anonymous reviewers.

$p = .223$, with no differences between breeds (Kruskal–Wallis test, $\chi^2$ (4) = 4.56, $p = .336$). Two subjects, however, seemed to rely on the touching cue: One Husky chose the cup touched *last* in 78 % of trials (Binominal test, $p = .001$), and one Labrador Retriever preferred the box touched *first* in 81 % of trials (Binominal test, $p \leq .001$).

There was no effect of age (Spearman correlations, Happy–Neutral: $r_{s\ (58)} = -.058$, $p = .664$; Happy–Disgust: $r_{s(58)} = -.102$, $p = .447$). We checked for possible learning effects within the study, but found no positive correlation between the proportion of correct subjects within each trial and the number of trials (Spearman correlations, Happy–Neutral: $r_{s\ (58)} = -.494$, $p = .037$; Happy–Disgust: $r_{s\ (58)} = -.095$, $p = .708$), indicating no learning effects.

### Control condition for the Huskies

For studies run in our indoor laboratory, we can rule out the use of any cues other than the ones given by the experimenter (e.g., see Bräuer et al. 2006; Riedel et al. 2008; Wobber et al. 2009). However, the Huskies were tested outdoors, and conditions were sometimes windy. Thus, instead of taking the experimenter's emotional reactions into account when choosing, these dogs may have simply been able to smell what was hidden in both boxes. We therefore decided to run a smell-control test with these dogs (with a twelve-month delay between the original test and the control test). We used the same procedure as before, that is, the boxes were baited with positive (i.e., sausage) and neutral (i.e., wood shavings) or negative (i.e., garlic) items, except that the experimenter always displayed a neutral facial expression upon opening the boxes. Subjects were presented with only nine trials per condition for a total of 18 trials, all presented in one session. The Huskies selected the box with food in 54.2 % (SEM = 3.78 %) of the trials in the Sausage–Wood Shavings condition and in 53.5 % (SEM = 3.69 %) of the trials in the Sausage–Garlic condition. Neither of these is above chance: Sausage–Wood shavings condition, $T^+ = 90.50$, $N = 16$, $p = .267$, $r = .27$; Sausage–Garlic condition, $T^+ = 87.00$, $N = 16$, $p = .351$, $r = .25$, Wilcoxon tests. Although we were aware of possible order effects and not all subjects that had participated in the original test were available at the time of the control session, we also compared these results directly to the Huskies' performance in the experimental conditions. Neither of the two comparisons revealed differences between these dogs' performance in the experimental and the control conditions: Happy–Neutral versus Sausage–Wood shavings conditions, $T^+ = 76.50$, $N = 16$, $p = .660$; Happy–Disgust versus Sausage–Garlic conditions, $T^+ = 42.00$, $N = 16$, $p = .178$, Wilcoxon tests.

## Discussion

Domestic dogs as a group—when tested in a highly controlled environment—were able to use some emotional expressions to find hidden food. In the Happy–Disgust condition, they selected the box to whose content E had reacted positively over an alternative to whose content E had reacted with disgust. They therefore identified the experimenter's attentional focus and interpreted the human's emotional expression as referring to the specific target (the object he was just looking at) and with a specific valence—much like 14-month-old human infants (Repacholi 1998). They did this even though the physical actions associated with all emotional signals and the two boxes were identical, which means that the dogs appeared to link the experimenter's emotional signals with the contents of the boxes, not the boxes themselves. Thus, the most plausible hypothesis is that dogs succeeded by relying on the human's emotional expressions to locate the hidden food. Since there were no learning effects, it is unlikely that the subjects' success was due to learning during testing. However, in the Happy–Neutral condition, where the experimenter reacted to the content of one box with happy emotions and to the other one neutrally, dogs showed no preference.

These dogs' failure in the Happy–Neutral condition might be due to difficulties in distinguishing between the happy and neutral emotional facial expressions. Interestingly, when great apes of all four species are presented with exactly the same paradigm (Buttelmann et al. 2009), they also cannot discriminate these two fairly similar human expressions. On the one hand, the difference between the happy and the disgusted expression is more pronounced and so perhaps this enabled the dogs to better discriminate between them. On the other hand, whereas in the Happy–Neutral condition only one expression (i.e., the happy display) was accompanied by a sound, in the Happy–Disgust condition, this was the case for both expressions. Thus, sound might be boosting dogs' (and great apes') ability to make use of human emotional expressions. Additionally, the way the neutral expression was presented might be problematic for subjects: Since the experimenter did not show any positive or negative affect but demonstrated a *still face*, this expression might have caused negative affect in our subjects as it does in human infants (Mesman et al. 2009), which might have caused their random choice. Unfortunately, since this condition was not included in the original study on human infants (Repacholi 1998), we can only speculate that human participants might have trouble in this condition as do dogs and great apes. Whether dogs, like human infants, indeed show a still face effect when presented with a neutral facial expression requires additional research specifically designed to address this question. Our results suggests that domestic dogs, like great apes, distinguish between human emotional expressions when they are very distinct and that it seems harder for them to distinguish between more similar expressions in a food finding context. It is a very interesting task for future research to investigate dogs' use of a great variety of human emotional expressions to locate hidden food and to check whether distinctiveness of the emotions involved allows the prediction the dogs' performance.

The results of the Huskies, the breed that was tested in the open air, were less clear. They selected the box to whose content the experimenter had reacted positively over an alternative to whose content he had reacted neutrally or with disgust in both conditions and showed a stronger preference than the other group of subjects in the Happy–Disgust condition. However, the two questions that arise are whether they succeeded based on the cues provided by the experimenter and whether their better performance in the Happy–Disgust condition is based on breed differences or on differences in testing environment. Answers to both of these questions come from the Huskies' performance in a control experiment consisting of two conditions that were run to check for the use of olfactory cues or any cues other than the ones provided by the experimenter. In these control conditions, the boxes contained exactly the same materials as they did in the experimental condition but now the experimenter provided only neutral cues, independently from content he found in the boxes. Although—as expected—the data revealed only small effects and the Huskies performed at chance level in both of these control conditions, their performance did not differ from that in the experimental conditions. This lack of difference most likely shows that in addition to the cues provided by the experimenter in the experimental conditions, the Huskies used some additional cues provided by the outdoor testing environment. Although these cues alone did not have enough effect to let the Huskies pass our test (as shown by their performance at chance level in the control conditions), they might have boosted the Huskies' performance in the experimental conditions. We therefore think that differences in testing environment rather than breed differences can explain differences in performance between the two groups of subjects tested. Future research needs to investigate huskies' ability to use of referential emotional expressions to locate hidden food in comparison with other breeds in highly controlled indoor settings.

It remains unclear whether the success of the dogs tested indoors in the Happy–Disgust condition is due to a biological predisposition they acquired during domestication to understand a human's emotional expressions as being referential, or whether individual subjects had learned the associations between specific emotional expressions and certain patterns of behavior during their ontogeny. Since subjects' age did not appear to be correlated with performance in our study, it seems unlikely that subjects had to learn the cues tested rather than being biological predisposed to be able to read these kinds of cues. Thus, although we cannot rule out the influence of human contact on the development of the ability to make use of human emotional expressions, we think that domestication might have played a major role in the development of dogs' ability to utilize human emotional expressions from very early in their ontogeny (e.g., Riedel et al. 2008). The fact that we did not find any breed differences in the use of human emotional expressions within the group of dogs tested in the laboratory shows that this ability, as the use of gaze/point cues to locate hidden food (Wobber et al. 2009), seems to be universal for, at least, different breeds of working dogs.

One important limitation of our results is that although dogs as a group chose the box with the positively evaluated content in the Happy–Disgust condition their individual levels of preference were relatively low. This makes us cautious regarding the robustness of dogs' knowledge about human emotional expressions as indicators for the location of food. In particular, certain procedural aspects of the experiment may have affected subjects' performance. For instance, we may speculate that subjects may have assumed that both boxes were baited (despite never experiencing that situation during the test), or the dogs may have had position biases that contributed to a noisier data set. We were able to show that those dogs that chose correctly in exactly 50 % of the trials did so because of side biases. They probably refused to switch sides because they were unable to use the cues provided by the experimenter and therefore did not know where to find the food. The intermittent reinforcement—they were rewarded in half of the trials—seemed to even make them resistant to the additional warm-up that was provided to those subjects that showed a clear side bias in the first session (see procedure). Additionally, the subjects' low performance may have been influenced by the fact that the subjects were distracted by more than one salient cue being present during the experimenter's demonstration. Before the experimenter gave his cues according to the content of a box, he gazed at this box, touched its lid, lifted the lid and then started to react emotionally. Thus, this procedure included, at least, two important cues for dogs: the experimenter's gaze and the touching of the boxes. Again, since Huskies, Retrievers and herding dogs in the study of Wobber et al. (2009) were shown to be able to reliably use a gaze cue, it seems plausible that the experimenter's handling of both boxes could have made a difference in our study. Although speculative, if for dogs touching a box is a more salient cue than emotional expressions, they might mainly pay attention to this cue and neglect the human's emotional expressions. Since the experimenter dealt with both boxes, they both were enhanced equally and dogs would choose randomly. However, our results do not support this hypothesis. When we analyzed whether dogs had a preference to approach the box touched (and gazed at) last by the experimenter, no effects could be found. If the touching or gazing cues were more important for dogs than others, this would have been revealed in this analysis. Therefore, the different cues included in our procedure cannot be made responsible for the weak performance of our subjects.

To make it easier for dogs to focus on the emotional cues provided by the experimenter, our procedure could be improved. That is, if a second experimenter opened the boxes or it was opened automatically for the first experimenter to inspect and react emotionally, this might have increased the subject's performance since then fewer possible cues would be provided by the first experimenter.[2] However, although the dogs' performance was lower than when presented with gazing and pointing cues in other studies (e.g., see Miklósi and Soproni 2006), their use of the emotional expressions as cues to locate hidden food still exceeded the effectiveness of other cues like glancing (e.g., see Soproni et al. 2001). Future studies should investigate which specific aspect of the human's emotional reaction drove the successful subjects' responses, as multiple facial and auditory cues were available. On the one hand, vocal intonation alone may be a more salient cue for the dogs compared to facial expression (as for human infants in social referencing tasks; Mumme et al. 1996). If so, they could have used tone of voice to infer emotional state in our study, ignoring the facial expressions entirely (for evidence on dogs' sensitiveness to humans' tone of voice see Mills et al. 2005; Scheider et al. 2011). On the other hand, evidence suggests that dogs pay close attention to humans' faces and their eyes in particular (e.g., Call et al. 2003).

In conclusion, previous research has demonstrated that domestic dogs use a number of experimenter-given communicative cues such as pointing or gazing (Hare and Tomasello 1999; Soproni et al. 2001, 2002). Here we have extended these findings to include the use of emotional expressions as being referential, something that might help to predict others' behavior and react accordingly. Whether both domestication and the level of interaction with humans within dogs' lifetime influenced domestic dogs' motivation or sensitiveness for those cues and whether domestic dogs understand the meaning behind emotional expressions and their link to desires is therefore an important task for future research.

[2] We are grateful for this suggestion to an anonymous reviewer.

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