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Dogs' (*Canis familiaris*) Attention to Human Perception: Influence of Breed Groups and Life Experiences

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Attending to the perception of others may help individuals gaining information from conspecifics, or help in competitive situations. Dogs (*Canis familiaris*) are attentive to humans' signals and their attentional state. We investigated whether dogs of different breed groups differ in their ability to pay attention to human's perception, first according to the genetic relatedness between dog breeds, and second according to working style differences. Once dogs had learned to leave forbidden food on the floor, they were confronted with 2 food items to which only they had unrestricted visual access. The owners saw either none or 1 food item through a transparent barrier. Our results showed that dogs pay attention to the perception of humans, whereby differences between breed groups became obvious. Within different genetic groups, ancient and hunting type dogs performed similarly, they were more attentive to their owners' perception than shepherd and the mastiff type dogs. When comparing dogs classified according to their working style, independent workers and family dogs were attentive to the owner's perception, while cooperative workers seemed not. The dogs' choice could not be explained by a general or training induced preference for eating behind an opaque screen, or by an influence of the owner's possible intention to prevent the dog from taking the food item he could see. Our study confirms that dogs are attentive/sensitive to human's perception, but genetic and working style differences among the breeds, as well as dog sport experiences explain part of the variation seen in their performance.

Keywords: attentiveness, breed group differences, *Canis familiaris*, cognition, dog

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Knowing and exploiting what others can and cannot see might provide several advantages for animals living in social groups. Bräuer, Call, and Tomasello (2004) suggested that knowing what others can see may help in competitive situations involving limited resources, and it may be advantageous particularly for subordinates, when deciding whether to approach and take a piece of food in the presence of a dominant individual (Bräuer et al., 2004). These aspects regarding the visual access of others have been documented in nonhuman primates, mostly in chimpanzees (*Pan troglodytes*) first in anecdotal reports (de Waal, 1982, 1986; Whiten & Byrne, 1988), and later also in experimental settings (Hare, Call, Agnetta, & Tomasello, 2000; Hare, Call, & Tomasello, 2006; Melis, Call, & Tomasello, 2006; Bräuer, Call, & Tomasello, 2007). Hare et al. (2000) tested chimpanzees in a food competition paradigm, where a subordinate and a dominant animal competed over two pieces of food. While the subordinate could see both pieces, the dominant saw only one. Subordinates preferentially chose the piece of food that was visible only to them. Call and Tomasello (2008) reviewed several studies assessing chimpanzees' and also orangutans' (*Pongo pygmaeus*; Shillito, Shumaker, Gallup, & Beck, 2005) understanding of others and concluded that, like humans, these species understand the actions of others not just in terms of overt behaviors, but also in terms of the underlying goals, and possibly, the intentions involved. Several studies indicate the presence of perception understanding in other primate and nonprimate animals living in complex social environment for example, rhesus monkeys (*Macaca mulatta*; Flombaum & Santos, 2005), lemurs (Sandel, MacLean, & Hare, 2011), dolphins (*Tursiops truncatus*; Xitco, Gory, & Kuczaj, 2004), scrub jays (*Aphelocoma coerulescens*; Emery & Clayton, 2001), ravens

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(*Corvus corax*; Bugnyar & Heinrich, 2005; Bugnyar, Stöwe, & Heinrich, 2004), goats (*Capra hircus*; Kaminski, Call, & Tomasello, 2006), and dogs (*Canis familiaris*; Bräuer et al., 2004; Kaminski, Bräuer, Call, & Tomasello, 2009).

Dogs have been shown to be attentive to human communication, attention and perception. They are able to find hidden food by following pointing gestures made with different parts of the human body (Miklósi, Polgárdi, Topál, & Csányi, 1998). Dogs beg for food preferentially from people who are able to see it (Gácsi, Miklósi, Varga, Topál, & Csányi, 2004; Virányi, Topál, Gácsi, Miklósi, & Csányi, 2004), they follow the gaze of a human more, if the head turning was preceded by the expression of communicative intent (Téglás, Gergely, Kupán, Miklósi, & Topál, 2012), and they are less likely to take forbidden food when a watchful human is present than when the human is absent or looking away (Call, Bräuer, Kaminski, & Tomasello, 2003; Virányi et al., 2004), or if there is an effective barrier between them and the human (Bräuer et al., 2004). Furthermore, they preferentially retrieve a toy that can be seen by both the dog and its owner (Kaminski et al., 2009). However, it has been argued that these findings might be explained by the dogs' reaction to specific stimuli in the human partner, for example, seeing certain parts of the human body, and therefore rather relying on their own perception of the situation, than having an understanding of the other's visual perception (Bräuer et al., 2013; Kaminski, Pitsch, & Tomasello, 2013). This argument was supported by Bräuer et al. (2013) finding that dogs payed attention to a silent approach to retrieve forbidden food, but not if their paw was visible to the experimenter during stealing, when they themselves could not see the experimenter. In contrast, in the study by Kaminski et al. (2013) dogs' were stealing more food when the treat was hidden in the dark and could not be seen by the owner independent of whether the dog could see the owner or not. In sum, most studies indicate that dogs attend to human perception, however, it is not clear how flexible and skilled dogs are in using this ability (for a review, see Bräuer, 2014). MacLean, Krupenye, and Hare (2014) combined pointing gestures with visual obstacles, and concluded that even though dogs seem to be skilled in both, following human gestures and exploiting information about another's visual perspectives, they may not integrate these skills in the way human children do (MacLean et al., 2014).

Alongside other factors, breed differences and ontogeny might affect the performance of dogs in such tasks. It is conceivable that breeds that have been extensively bred for cooperating and working closely together with humans, such as working and herding dogs, might pay more attention on the human's perception than other more independent working breeds, for example, some hunting, or ancient dogs. Such breed and breed group differences were found in different tasks including communication with humans. Udell, Ewald, Dorey, and Wynne (2014) examined Border Collies (a herding dog), Airedale Terriers (a hunting dog), and Anatolian Shepherds (a livestock-guarding dog) in a human pointing task. Border Collies were the most successful and performed above chance as well as the Airedale Terriers did. The Anatolian Shepherds performed at chance level, but improved after some training trials (Udell et al., 2014). Another pointing study comparing New Guinea Singing Dogs (a primitive breed) with dogs from "modern" breeds (Wobber, Hare, Koler-Matznick, Wrangham, & Tomasello, 2009) showed that also a primitive breed with little human contact was able to use the communicative cues provided. When communicating with the owner, dogs belonging to the herding dogs (Belgian Shepherd, Border Collie, Pumi, Mudi, Kuvasz) looked back to their owners more often than hunting dogs (Hungarian Vizsla, Airedale Terrier), but both had the same efficiency in solving a specific detour task (Pongrácz, Miklósi, Vida, & Csányi, 2005). The authors suggested that looking back to the owner might be a general habit of herding dogs to frequently check the shepherd's possible commands or position during work with the flock (Pongrácz et al., 2005). Further studies indicate that Retrievers look more at the human's face than German Shepherds or Poodles (Jakovcevic, Elgier, Mustaca, & Bentosela, 2010), and in an unsolvable task, in contrast to Pongrácz et al. (2005) both herding and hunting dogs showed more human-directed gazing behavior than primitive and molossoid dogs (Passalacqua et al., 2011). Paying attention to human communication, also the readiness to look into human's face may favor a dog's attention to human perception.

The aim of the present study was to further investigate the attention of dogs to human perception, with a focus on breed group differences, on one hand based on their genetic relatedness (using Parker et al., 2004), and on the other hand based on their working style, their use in human society. We applied a food competition paradigm similar to that of Bräuer et al. (2004). After being trained that they should not approach the food, dogs were presented with two pieces of food behind two barriers. Whereas dogs had visual access to both, the owner could see only one or none. We expected dogs that were bred for cooperating and working closely together with humans, such as working and herding dogs, to pay more attention to human perception than independent working dogs, such as some hunting dog breeds. Training and experience is affecting the dogs' performance in communicative tasks (e.g., Udell et al., 2014). Several dog sport activities, such as agility or obedience training, favor that dogs pay more attention to their owner's body language and signals. Therefore, we expected that dogs intensively working with their owners would be more sensitive to the owner's perception than dogs with less or no dog sport experience. To investigate these effects, we tested 187 dogs of different breeds, with different "dog sport" and "dog school" experiences.

To exclude possible alternatives explaining the dogs' choice behavior, three control tests were conducted. In a first control experiment we investigated whether the dogs' choice might be based on human body cues. Therefore, we asked the owners in the test to try to influence their dog's choice, without giving any obvious signals, like verbal commands, but for example by staring at the dog to try to prevent the dog from eating the food; slight body movements were allowed but not lifting the arms or moving the legs. In addition, dogs might have a general preference to eat food behind a screen, for example, due to lifelong experience for eating food behind an obstacle. Therefore, we exposed dogs to two food items to which only they had unrestricted visual access, and the owner could see only one. However, also the training itself may have an effect on the dogs' choice; if it is forbidden to take the food they may always prefer to eat behind an opaque screen. Therefore, we tested dogs, after receiving the same training as during the main test, but the owners were not present afterward, when they had the chance to get the food.

Main Experiment

In the main experiment, we investigated the influence of breed groups and training experience on the dogs' attention to human perception and readiness to integrate such information in their behavior when taking forbidden food in the presence of their owner.

Materials and Methods

Test area and subjects. The experiment took place outdoors in a quiet enclosure at the University of Zurich-Irchel, Switzerland. Concrete walls on three sides surrounded the enclosure, and on the remaining side there was an empty enclosure separated by a high fence covered with a screen made of bamboo. The entrance was a gridded door covered with plastic opaque sheeting. Inside the enclosure, the test area an inner area was built with opaque plastic sheets, which was used as the main test area (see Figure 1). To the main test area, there were two entrances opposite each other and in the middle the possibility to place two T-shaped barriers on the ground, which had a height of about 30 cm. It was possible to hide a box with food on it behind the barriers. The experiment was videotaped with a digital video camera (JVC, GZ-MG330HE, Yokohama, Japan).

One hundred eighty-seven (84 male, 103 female) domestic dogs of 56 different breeds participated in the main experiment. All tested dogs lived either as a single dog or with other dogs with private owners and were between 0.5 and 14 years of age (M_{age} = 5.4 years). The dog's breed was assigned in a first analysis based on their genetic type to one of the four breed groups defined by Parker et al. (2004): the ancient type (N = 90, M_{age} = 5.1 years), the Shepherd type (N = 28, M_{age} = 5.8 years), the hunting dog type (N = 38, M_{age} = 6.6 years), and the Mastiff type (N = 31, M_{age} = 4.6 years). In a second analysis, we assigned all of the tested dogs to three breed groups based on their working style (Gácsi, McGreevy, Kara, & Miklósi, 2009): independent working style (N = 80, M_{age} = 5.5 years; e.g., sight hounds, ground scent hunting dogs, Siberian Huskies), the cooperative working style (N = 47, M_{age} = 5.8 years; used for herding, or police work, e.g., Shepherds, Boxers), and the family style (N = 60, M_{age} = 5.0 years; e.g., Lhasa Apso, Medium Poodle, English Bulldog; see Table 1). The dog's training and dog sport experiences were noted.

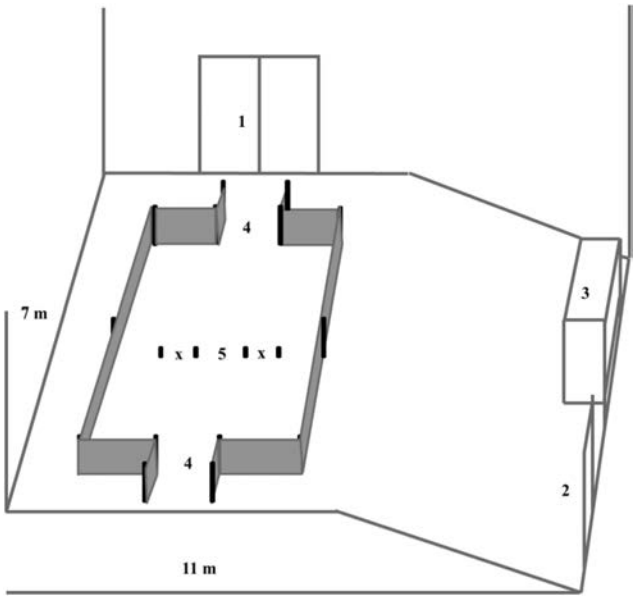


Figure 1. Outline of the test area and the main test area. (1) The test animals entered the enclosure through this door. (2) Entrance out of the building. (3) Position of the elevated observation cabin inside the building. (4) Start position of the dog or the dog owner. (5) The location (x) where two T-shaped bars can be fixed.

Experimental setup.

Training phase. Before the training started, dogs were allowed to explore the test area until they lost interest. The owner and the dog then left the test area, and two dog biscuits were placed, each on the top of a plastic box inside the main test area. The boxes were used to make sure that both, the dog and the owner could always clearly see the food location. During the first stage of the training the two boxes were situated in one corner of the main test area. The corner was randomly determined before the experiment started. After entering the main test area the dog owner approached the two boxes with his or her dog either on a leash or without, depending on the training stage of the dog. As soon as the dog tried to take the food, its owner gave a well-known command such as "no" or "leave it." If the dog obeyed by stopping its movement, or turning its head away, or if the dog offered an alternative behavior (instead of trying to take the food) such as looking at the owner and ignoring the food, the owner rewarded the dog with a piece of biscuit out of a bum bag. To prevent the dog from eating the food, in case it was not listening to the command given, the owner was allowed to step vigorously between the food and the dog. If a dog, nevertheless, was able to get a piece of food, the owner was asked to step aside with the dog, the food treat was then replaced and the training was continued. After 1 min of training, measurement started when the dog and the owner entered the main test area, the owner and his dog left the main test area and in case the dog repeatedly tried to get the food (with or without being leashed), or was even successful, the boxes were moved to another corner. The corner was randomly chosen from the remaining three corners before the experiment started, and this first training step was repeated. If the dog had ignored the food, or did not try to get the food when it was on the leash, the owner and the dog entered the test area again, but without a leash, while the rest of the training remained the same except that the owner was asked not to reward the dogs with food more then once. The dog conducted as many trials as were necessary until it left both food items on the boxes for 1 min and the owner did not have to remind the dog more than once. Afterward, the boxes were placed in the middle of the main test area (see Figure 2a) and the training continued until the dogs reached the same criterion again.

During the next training stage, the dog was brought to one entrance (Figure 1, Location 4) by the experimenter, while the owner stayed on the opposite side and was instructed to observe the dog, but not to call it except to forbid taking the food if it attempted to do so. After 1 min, the owner called the dog and rewarded it, if the dog came without having eaten the food. If it was not necessary to give the commando "no" more than once, and if the dog did not go straight away to one of the biscuits when released, the dog had reached the test criteria.

Table 1
Number of Dogs per Breed and Breed Group Participating in the Main Experiment

Breed	Number of tested dogs	Group based on genetics	Group based on working style
Afghan Hound	6	Ancient type	Independent working style
Airedale Terrier	1	Hunting dog type	Cooperative working style
Akita Inu	5	Ancient type	Family style
Alaskan Malamute	8	Ancient type	Independent working style
American Cocker Spaniel	2	Hunting dog type	Family style
Australian Shepherd	1	Hunting dog type	Cooperative working style
Basenji	7	Ancient type	Independent working style
Beagle	1	Hunting dog type	Independent working style
Belgian Sheepdog	4	Shepherd type	Cooperative working style
Belgian Tervueren	6	Shepherd type	Cooperative working style
Bernese Mountain Dog	2	Mastiff type	Family style
Border Terrier	1	Hunting dog type	Independent working style
Borzoi	3	Shepherd type	Independent working style
Boxer	3	Mastiff type	Cooperative working style
Bull Terrier	2	Mastiff type	Family style
Bullmastiff	1	Mastiff type	Family style
Cairn Terrier	1	Hunting dog type	Independent working style
Chihuahua	1	Hunting dog type	Family style
Chinese Shar-Pei	7	Ancient type	Family style
Chow Chow	5	Ancient type	Family style
Collie	6	Shepherd type	Cooperative working style
Curly-Coated Retriever	1	Hunting dog type	Cooperative working style
Dachshund	2	Hunting dog type	Independent working style
Doberman Pinscher	2	Hunting dog type	Cooperative working style
English Bulldog	3	Mastiff type	Family style
English Pointer	1	Hunting dog type	Cooperative working style
Flat-Coated Retriever	1	Hunting dog type	Cooperative working style
German Shepherd	5	Mastiff type	Cooperative working style
Golden Retriever	3	Hunting dog type	Cooperative working style
Great Dane	1	Hunting dog type	Family style
Greater Swiss Mountain Dog	12	Mastiff type	Family style
Greenland Dog	1	Ancient type	Independent working style
Irish Setter	3	Hunting dog type	Cooperative working style
Irish Terrier	2	Hunting dog type	Independent working style
Irish Wolfhound	3	Shepherd type	Independent working style
Jakuten Laika	1	Ancient type	Independent working style
Keeshond	1	Hunting dog type	Family style
Kerry Blue Terrier	2	Hunting dog type	Independent working style
Kuvasz	1	Hunting dog type	Independent working style
Labrador Retriever	2	Hunting dog type	Cooperative working style
Lhasa Apso	1	Ancient type	Family style
Medium Poodle	2	Hunting dog type	Family style
Miniature Schnauzer	1	Hunting dog type	Family style
Newfoundland	2	Mastiff type	Family style
Pekingese	1	Ancient type	Family style
Pomeranian	2	Hunting dog type	Family style
Standard Poodle	1	Hunting dog type	Cooperative working style
Pug Dog	1	Hunting dog type	Family style
Rottweiler	1	Mastiff type	Cooperative working style
Saint Bernard	1	Shepherd type	Family style
Saluki	5	Ancient type	Independent working style
Samoyed	3	Ancient type	Independent working style
Shetland Sheepdog	5	Shepherd type	Cooperative working style
Shiba Inu	7	Ancient type	Family style
Siberian Husky	32	Ancient type	Independent working style
Tibetan Terrier	1	Ancient type	Cooperative working style
West Highland White Terrier	1	Hunting dog type	Independent working style

The number of training trials under each condition was noted. In total, the dogs needed between three and 21 (M = 5.4) training trials.

Testing phase. In the absence of the dog and its owner, the experimenter deposited two dog biscuits on the two plastic boxes (as during the training phase) behind the two T-shaped bars that were placed in the middle of the main test area. Two test conditions were conducted (Figure 2b, 2c): (a) hidden–pseudohidden; one T-shaped bar was transparent the other was a normal, opaque one, and (b) hidden–hidden (controlling for a side bias due to the

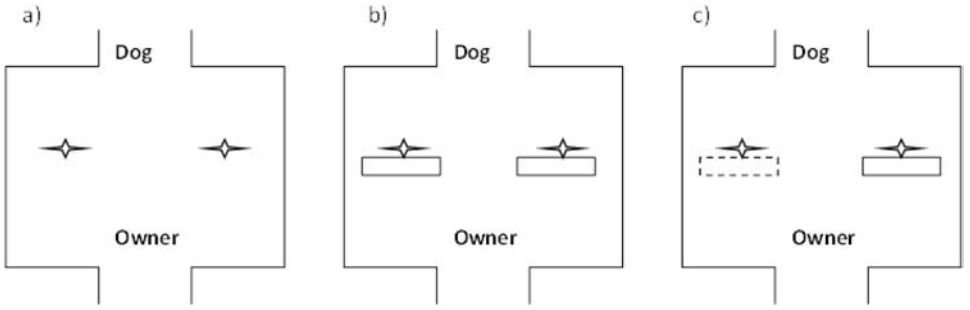


Figure 2. Relative position of food, visual barrier, owner and dog during (a) the last training phase; (b) hidden–hidden condition, and (c) hidden–pseudohidden condition in the testing phase; in half of the dogs, the transparent screen was located on their right, in the other half on their left side.

test area). There were two opaque T-shaped bars inside the test area. Half of the dogs (half of the males and half of the females) started with Condition 1, while the other half began with Condition 2. In Condition 1, for half of the dogs, the transparent screen was located on the right side, for the other half, on the left side. The T-shaped bars had a height of 30 cm and did not provide a hiding location for the dogs. Afterward, the experimenter brought the dog directly to its start position, at one of the two randomly selected opposite entrances (the same as during the last training step), while the owner went to the other side. The experimenter made sure that dogs entered the main testing area with no prior experience of the visual perspective available from where their owners entered. During the test only the dogs had unrestricted visual access to the dog biscuits. As soon as both, dog and owner were at their start position the experimenter closed her eyes and after counting 5 s, the dog was released. The dog owners were asked not to move and not to talk, but to observe their dogs attentively, following their movement with their gaze, throughout the whole experiment. When the dogs ate the two biscuits or if they sat or lay down for half a minute, the test was stopped. If a dog did not eat any of the biscuits, both dog and owner left the main test area at the same time and after a break of 1 min, the test was repeated; a dog had a maximum of three chances to choose. All dogs that took at least one food item were tested once in both conditions. To provide similar preconditions, they had another training session between the two test trials and they had to reach the same test criterion as before (a video of the test is available as supplemental material).

Statistical analysis.

Condition 1: Hidden–pseudohidden. To analyze whether the dogs chose first the food behind the opaque screen above chance, we applied a binomial test overall and also at the group level. To investigate the influence of breed group, dog sport activity, participation in dog school, age, sex, the position of the transparent barrier, trial (tested as first or second in this condition), and castration on the dog's first choice, we calculated a generalized linear model (GLM) using a quasibinomial distribution (controlling for overdispersion). A dog was assigned to be active in dog sports if an owner regularly participated in agility classes, or was active in Begleithundeprüfung (testing as a companion) preparation classes, internationale Prüfungsordnung (IPO; international testing), French Ring, or obedience classes. Sports where the dogs were mainly physically active, for example, sledging was not included in the dog sport group.

Not all dogs took both food items. Therefore, we conducted a binomial test to analyze behind which screen a dog ate the food item if it chose only one. Some dogs refused to take any of the food items. This prompted us to analyze the influence of breed group, participation in dog sport activity, dog school, age, sex, and castration on whether a dog took at least one food item or was not choosing by using a generalized linear model with the quasibinomial distribution (controlling for an overdispersion).

Condition 2: Hidden–hidden. To analyze the dogs' choice behavior when both screens looked the same we calculated a generalized linear model using the quasibinomial distribution, controlling for overdispersion, to investigate the influence of breed group, dog sport activity, participation in dog school, age, sex, trial (tested as first or second in this condition), start position, and castration on the dogs' first choice.

Furthermore, we analyzed the number of training trials a dog needed to reach the test criterion for both conditions with a generalized linear model using a quasi-Poisson distribution (controlling for overdispersion). We analyzed whether breed group, dog sport activity, participation in dog school, age, sex, and castration had an influence on the number of training trials a dog needed.

Twenty percent of the videos were coded by a second person. The choice behavior was scored perfectly reliably Cohen's $\kappa = 1.0$, $N = 76$. The analysis was done with R Version 3.1.2 (R Core Team, 2014).

Results

Condition 1: Hidden–pseudohidden. Sixteen out of the total 187 tested dogs (8.6%) did not take any piece of food and were therefore excluded from the following analysis. Overall, the tested dogs chose more often first the dog biscuit that could not be seen by the owner (binomial: $p < .001$, 63.7% [109 out of 171]). However, at the group level based on their genetic type, only the dogs from the ancient type and the hunting dog type showed the same pattern, but not the dogs from the Shepherd type and Mastiff type (see Table 2 and Figure 3). Analyzing the groups based on the working style of the dogs we found a preference for the opaque screen in the independent working style and in the family style group, but not in the cooperative working style group (see Table 2 and Figure 4).

Table 2
Performance of the Different Breed Groups

Group	Percentage choosing the opaque screen (all dogs included)	Binomial test all dogs included	Binomial test without dogs active in dog sports
Ancient type	66.7% (54 out of 81)	$p = .004^*$	$p = .002^*$
Shepherd type	56% (14 out of 25)	$p = .69$	$p = .11$
Hunting dogs type	73.5% (25 out of 34)	$p = .009^*$	$p = .002^*$
Mastiff type	51.6% (16 out of 31)	$p > .99$	$p = .82$
Independent working style	66.2% (45 out of 68)	$p = .010^*$	$p = .001^*$
Cooperative working style	55.6% (25 out of 45)	$p = .55$	$p = .12$
Family style	67.2% (39 out of 58)	$p = .012^*$	$p = .049$

* Significant values with α-level = .025.

When analyzing the dog's first choice to go either to the food item behind the transparent or opaque screen we found no influence of age, sex, the position of the transparent barrier (right or left side), trial (first or second), participation in dog school, or castration (GLM: age: $\chi^2_1 < 0.01$, $p = .97$; sex: $\chi^2_1 = 0.08$, $p = .78$; position transparent barrier: $\chi^2_1 = 2.23$, $p = .14$; trial: $\chi^2_1 = 1.88$, $p = .17$; dog school: $\chi^2_1 < 0.01$, $p > .99$; castration: $\chi^2_1 = 0.27$, $p = .60$). However, we found an influence of whether the dog participated regularly in dog sports (GLM: $\chi^2_1 = 5.626$, $p = .018$). Dogs that were active in dog sports such as agility, IPO, or obedience, showed no preference for taking one of the food items first, but dogs without dog sport experience preferentially chose the food behind the opaque barrier (binomial: dog sports yes: $p > .99$, 48.9% [22 out of 45]; no: $p < .001$, 69% [87 out of 126]; Figure 5).

In the different breed groups a different proportion of dogs were active in dog sports. In the ancient type, 14.8%; in the Shepherd type, 60%; in the hunting dog type, 14.7%; and the Mastiff type, 41.9% of the dogs that took at least one piece of food were active in dog sports. However, excluding the dogs participating in dog sports for another preference analysis on the group level, we found a similar result (see Table 2). When looking at the groups based on the dogs' working style, only 8.8% of dogs in the independent working style category, 55.6% in the cooperative working style, and 24.1% in the family style group were active in dog sports. After excluding the dogs activity in dog sports we found a similar pattern as before with dogs choosing above chance the opaque screen in the independent working style group, but not in the cooperative working style and also not in the family style group (after controlling for multiple testing; see Table 2), indicating that dog sport activity cannot explain the differences found between the groups.

Some of the dogs (7% or 11 dogs) chose only one piece of food. Of these 7%, most dogs (91% or 10 dogs) ate only the food item behind the opaque screen (binomial: $p = .012$). In all dog groups we found individuals that took only one piece of food (ancient type, 4.9% [four dogs]; Shepherd type, 8% [two dogs]; hunting dog type, 10.5% [four dogs]; Mastiff type dogs, 3.2% [one dog]; independent working style, 5.9% [four dogs]; cooperative working style, 2.2% [one dog]; family style, 10.3% [six dogs]).

Condition 2: Hidden–hidden. When both food items were invisible to the owners, but visible to the dogs, the test animals showed a preference for one of the two sides of the test area, that is, they preferred the side further away from the observation cabin (GLM: $\chi^2_1 = 9.860$, $p = .002$). In addition, age had an influence on the dogs' choice of food item (GLM: $\chi^2_1 = 7.258$, $p = .007$). While younger dogs tended to go to the right side, with increasing age they preferred to go to the left side. However, we found no influence of sex, group, castration, dog sports, participation in dog school or trial (GLM: sex: $\chi^2_1 = 0.10$, $p = .76$; group [based on genetics]: $\chi^2_3 = 1.37$, $p = .71$; group [based on working style]: $\chi^2_2 = 2.43$, $p = .30$; trial: $\chi^2_1 = 0.92$, $p = .34$; castration: $\chi^2_1 = 3.27$,

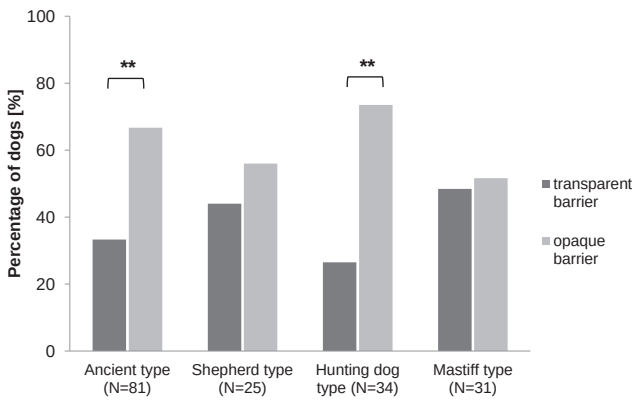


Figure 3. Influence of breed group, based on genetic grouping, on the dogs' first choice in the hidden–pseudohidden condition. (** $p < .01$, N = number of tested dogs).

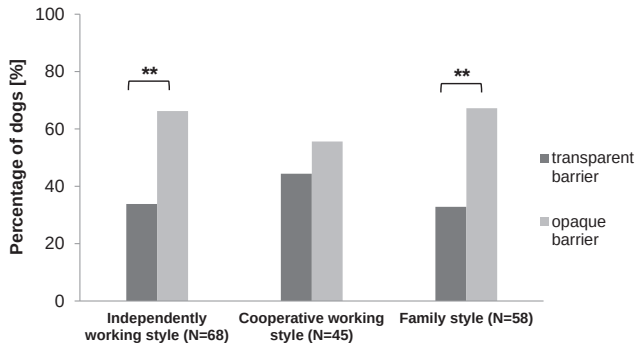


Figure 4. Influence of breed group, based on working style, on the dogs' first choice in the hidden–pseudohidden condition. (** $p < .01$; N = number of tested dogs).

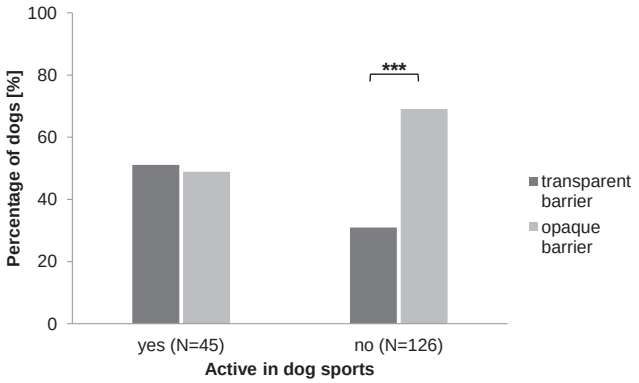


Figure 5. Influence of dog sport activity on the dogs' first choice in the hidden–pseudohidden condition. (*** $p < .001$, N = number of tested dogs).

$p = .07$; dog sports: $\chi^2_1 = 0.03$, $p = .42$; dog school: $\chi^2_1 = 0.56$, $p = .45$).

Number of training trials. Analyzing the number of training trials a dog needed to reach the criterion (all 187 dog included) we found an effect of group based on genetics (GLM: $\chi^2_3 = 9.115$, $p = .028$), indicating that the dogs from the Shepherd type needed fewer training trials than the dogs belonging to the ancient type (GLM: $t = 2.752$, $p = .0062$), hunting dog type (GLM: $t = 2.561$, $p = .011$), and the Mastiff type (GLM: $t = 2.296$, $p = .023$) groups. However, when analyzing the group effect based on the dogs' working style we found no effect (GLM: $\chi^2_2 = 1.79$, $p = .41$). Furthermore, castrated dogs needed more training trials than intact dogs (GLM: $\chi^2_1 = 22.674$, $p < .001$). We found no effect of age, sex, whether they did extensively dog sports with their owner, and whether they had visited a dog school, (GLM: age: $\chi^2_1 = 1.32$, $p = .25$; sex: $\chi^2_1 = 0.09$, $p = .76$; dog school: $\chi^2_1 = 1.83$, $p = .18$; dog sports: $\chi^2_1 = 0.01$, $p = .91$).

Control Experiments

To exclude the possibilities that subtle cues given by the owner or a preference of dogs to eat behind a certain screen explained the observed behavior of the dogs, we performed additional control experiments.

Influence of Owner

Because dogs are sensitive to human gestures (e.g., Virányi et al., 2004) it is conceivable that they also are capable of detecting and interpreting subtle gestures and movements even involuntarily exhibited by their owners, similar to what is described as the Clever Hans effect (Hediger, 1981). To rule out such an effect, the owners were asked to try to influence their dog's choice in the first control experiment.

Materials and method.

Subjects and experimental setup. Sixty-six (21 male, 45 female) domestic dogs of different breeds and mongrels participated in this first control experiment. The experimental procedure was the same as described in the main experiment with one exception: After a successful training and before starting the test, the dog owner was informed about the food item that was forbidden to take and that the owner should try to influence the dog not to go there. Furthermore, the owner was informed that it did not matter if the dog goes to the other side. When trying to influence the dog's choice they were not allowed to use their voice or any obvious gestures such as raising their arms or making a step toward the dog. The owners did not get any further instructions except that they should keep observing their dog in both test conditions. In the condition hidden–hidden half of the dogs were not allowed to go to and eat the food from the right side, the other half were not allowed to go and eat the food from the left side. In the condition hidden–pseudohidden half of the dogs were not allowed to go to the transparent barrier and half of the dogs were not allowed to go to the side with the opaque barrier.

Statistical analysis. When testing the influence of the owner on the dogs' behavior, one dog refused further participation in the test after being tested in the hidden–hidden condition and was therefore excluded from this analysis. The statistical analysis remained the same with the difference that only the position of the forbidden barrier, and trial (first or second), and new the group (forbidden to take behind the transparent or behind the opaque screen) were included into the model. 20% of the videos were coded by a second person. The choice behavior was scored perfectly reliably Cohen's $\kappa = 1.0$, $N = 28$.

Results. When the owners tried to influence their dog's choice 9.2% (or six out of 66) of the dogs chose only one piece of food. All of them took only the food item behind the opaque screen (binomial: $p = .031$). For half of these dogs ($N = 3$), the owner tried to influence them not to go to the opaque screen.

The dogs' choice to take first the food item behind the transparent or the opaque screen was independent of whether the owner tried to forbid the dog to go to one of the two food items (GLM: $\chi^2_1 < 0.01$, $p = .95$). In both groups, opaque and transparent screens forbidden, the dogs chose more often first the food behind the opaque screen (binomial: opaque forbidden: $p = .014$, 72.7% [24 out of 33]; transparent forbidden: $p = .020$, 71.9% [23 out of 32]). Furthermore, we found no influence of whether they had the hidden–hidden condition before or after this test, and we found no influence of whether the place where it was forbidden to go was on the right or left side of the dog (GLM: trial: $\chi^2_1 = 0.13$, $p = .72$; side: $\chi^2_1 = 0.40$, $p = .53$).

In the hidden–hidden condition we found no significant effect of the owner's effort to influence the dog in its choice or whether the dogs were first tested in the hidden–hidden or in the hidden–pseudohidden condition (GLM: influence owner: $\chi^2_1 = 1.69$, $p = .19$; [left side forbidden: 62.5% chose right side; right side forbidden: 45.5% chose right side] trial: $\chi^2_1 = 1.34$, $p = .25$). As in the main experiment, the dogs had a preference for one side in the test area (opaque screen furthermost from the observation cabin (see Figure 1; GLM: $\chi^2_1 = 4.347$, $p = .037$).

Screen Preferences

To test for a possible preference to eat behind one of the two different screens, we tested dogs in a first screen preference test without any previous training and in a second screen preference

test we tested the dogs after the training without the owner present.

Materials and method.

Subjects and experimental setup. When assessing for a dogs' screen preference without any prior training where food was forbidden to take, we tested 42 (14 male, 28 female) domestic dogs of different breeds and mongrels. First the dogs had time to explore the test area. Afterward, dog and owner left the area while the screens, one transparent and one opaque, were installed in the effective test area and two food items were placed behind them. While the owner went to the start position on one side of the effective test area, the dog was brought to the opposite side without having seen the owner's perspective. Only the dogs had unrestricted visual access to the food. After 5 s, the dog was released and could choose between the food items. The owner was asked to observe her/his dog attentively. The first choice of the dog was noted. In half of the dogs the transparent screen was located on their right, in the other half on their left side.

In the second screen preference test, we tested 19 (6 male, 13 female) domestic dogs of different breeds and mongrels. The dogs and their owners participated in the same training procedure as described in the main experiment. After reaching criterion the dog and the owner left the test area while the screens, one transparent and one opaque, were installed and the food items placed behind them. In half of the dogs the transparent screen was on their right side, in the other half on the left. While the owner went to the start position on one side of the effective test area, the dog was brought to the opposite side without having seen the owner's perspective of the effective test area. The owner observed the dog for 3 s, then turned around and left the test area. After the door was closed behind the owner, the dog was released.

Statistical analysis. For both screen preference tests we calculated a binomial test to assess the dogs' preference of one of the screens.

Results. In the first screen preference test, when the dogs were tested without a prior training we found a preference toward the transparent screen (binomial: $p = .044$; 28 out of 42 chose the transparent screen). When the dogs were tested without their owners present, but after the usual training session, we found no preference for either of the two screens (binomial: $p = .65$, 11 transparent, eight opaque barrier).

Discussion

When choosing between two forbidden food items, dogs approached first, or only, the one they and not the owners had visual access to, but there was variation in the performance between the breed groups depending on their genetics and selection for specific working styles, as well as on the experience in dog sport activity. Dogs, based on their genetics assigned to the ancient type and hunting dog type as well as the dogs based on their working style assigned to the independently working style, and the family style group ate first the food item behind an opaque screen, indicating that they payed attention to the owner's perception. The dogs assigned to the other genetic groups, the Shepherd type, the Mastiff type, as well as the cooperative working style group, chosen randomly. Similarly, dogs active in a variety of dog sports, such as obedience, agility, Begleithundeprüfung, IPO, or French Ring courses, activities in which they have to pay attention to the owners' commands and movements, did not differentiate between the two forbidden food treats.

A higher proportion of dogs in the Shepherd type and Mastiff type dogs (60% and 42%, respectively) were active in dog sports than compared with dogs belonging to the hunting type or ancient type dogs (14.7% and 14.8%, respectively). This was also the case in the group division based on working style: In the cooperative working style group most of them (55.6%) were active in dog sports, while only a minority in the independently working style (8.8%) and family style group (24%) did so. Considering these results together could indicate that the breed-group differences observed were caused by the high proportion of dogs being active in dog sports in the Shepherd type and Mastiff type dogs, respectively, the cooperative working style groups. However, excluding those dogs that were active in dog sports from the group analysis, we found a similar result, suggesting there may be a genetic influence on this behavior. Earlier studies (e.g. Pongrácz et al., 2005; Passalacqua et al., 2011) indicated that cooperative working dogs / shepherd dogs, show a high tendency to look at their owner during different tasks. Taking these results together with our findings, indicates that these dog breeds may wait for a command or "help" in the sense of a signal as to what to do, rather than looking at their owner to detect the owners' perception.

Despite the finding that some breed groups chose at chance level between the two food items, in all groups independently on how we divide the breeds, we found dogs that chose only the food item behind the opaque barrier and refused to eat the one behind the transparent screen, but they ate both of them when provided with two opaque screens. Therefore, these individuals seemed to be sensitive to the perception of their owners. It is plausible that differences in the individual's personality and/or different experiences during lifetime, besides dog sport activities, have had an influence on the dog's performance. D'Aniello and Scandurra (2016) reported that Labrador Retrievers living in a kennel looked less often and later back at the human in an unsolvable task than Labrador Retrievers kept as pets. Independent of the breed group, the majority of the tested dogs lived as single dogs in close contact with their human family and spent most of their daytime together with their owners. Because the owners' daily activities differ, the variability in their life experience is quite large. However, this variability was true for all dog groups tested and therefore, cannot fully explain the differences found between the groups. Further studies are needed to explore the effects of ontogeny in more detail.

Dogs assigned to the Shepherd type and cooperative working style group are known for their willingness to learn and to obey (Hart, 1995). This is reflected in our experiment with the Shepherd type group needing fewer training trials than the others. However, this result is not reflected when dividing the groups based on their working style, where we found no difference between the groups. This finding might be explained by dividing the tested dog breeds only into three groups based on their working style. When investigating the trainability differences between dog breed clusters Turcsán, Kubinyi, and Miklósi (2011) found a better trainability in herding dogs than in the other groups, as well as a better trainability in sporting dogs (dogs mostly used for cooperative hunting) than in nonsporting dogs. Furthermore, when analyzing the breeds

based on genetic background, they found that in the herding/sighthound cluster as well as the hunting breeds, the dogs were more trainable than breeds with ancient Asian or African origin (Turcsán et al., 2011). Tonoike et al. (2015) found similar results. Based on a questionnaire survey, they found that sight hounds and herding dogs were similar trainable as working dogs but better trainable than the other tested groups, for example, retrievers, mastiff-like dogs, toy dogs. In our study we find in all three groups (division based on working style) dog breeds that are more or less trainable according to Turcsán et al. (2011). Independent of the breed group, we found that neutered and spayed dogs needed more training trials than intact individuals. Serpell and Hsu (2005) investigated the relationship between trainability and castration and found an increase in trainability among castrates only in male Shetland sheep dogs and Rottweilers. A slightly different result was reported by Kubinyi, Turcsán, and Miklósi (2009), who found that neutered females and intact males were more easily trained than neutered males and intact females. However, both studies were based on questionnaires and not an analysis of the dog's behavior under a standard test condition. For a better understanding of this possible interaction between trainability and castration more experiments are needed.

Overall, the tested dogs chose preferentially the food item that could not be seen by the owner. Considering that the dogs are sensitive to human communicative cues (e.g., Miklósi et al., 1998; Gácsi et al., 2004; Virányi et al., 2004) it is possible that they are reacting to subtle cues of their owner and therefore avoid the food behind the transparent screen. Throughout the whole test the face of the owner was always orientated to and visible for the dog. In addition, in a first control test the main experiment was repeated with the owners instructed to try to influence their dog's choice, but without verbal commands or obvious gestures like moving the arms or legs. However, the owner failed, the result was the same as during the main experiment. In both groups (food forbidden either behind the opaque or behind the transparent barrier) the dogs that took only one food item chose only the one behind the opaque barrier. Therefore, it is unlikely that the owners were able to influence their dog's choice during the main experiment, and we can exclude the possibility that dogs responded to overt cues/signals of the owner, as had been suggested by Kaminski et al. (2009, 2013) or Udell and Wynne (2008). This finding is in line with a study about the Clever Hans effect in a pointing study in dogs (Schmidjell, Range, Huber, & Virányi, 2012). The authors showed that misinformed owners were unable to influence their dogs' choice in a two-way object-pointing task. The owners were only successful if they were allowed to actively influence their dogs, that is, guiding the dog to the desired food location (Schmidjell et al., 2012). One might still argue that we do not have proof in our experiment that the owners really tried to influence their dogs. Even though not significant, the hidden–hidden condition might indicate that there was the will to influence their dogs because when the left side was forbidden, a higher proportion of dogs (62.5%) chose the right side, and when the right side was forbidden, 54.5% chose the left side.

Lifelong experiences on one hand and immediate training induced preferences on the other hand might have caused a general preference for the opaque screen. However, when dogs had not yet received a training phase to not take the food, we found even a preference for them to take the food behind the transparent screen. Furthermore, in a third control experiment, after having received the training, the owner left the test area before the dogs had the chance to choose between the food items. In the absence of the owner the dogs showed no preference for any of the two food items. These results indicate the owners' presence and the dogs' knowledge that taking the food was forbidden caused the dogs' to take the owners' perception into account when choosing a food piece.

When the dogs chose between two food items that could not be seen by the owner, they had a preference for the food item behind the barrier on the right side when entering the test enclosure (see Figure 1, Location 1). We were unable to determine the reason for this. However, we did not find such a preference when the dogs were tested in the hidden–pseudohidden condition. In the hidden–hidden condition there was no necessity for not choosing randomly or to rely on a side preference. The fact that they were giving up this side preference in the hidden–pseudohidden condition implies that they were basing their decision on additional factors. Furthermore, in contrast to the hidden–pseudohidden condition, all dogs in the hidden–hidden condition always took all food items. These two aspects together indicate that the dogs took the visual perception of their owners into consideration while choosing between the two food items in the hidden–pseudohidden condition, and are in line with other studies suggesting that dogs have some understanding of their owner's visual perception (Bräuer et al., 2004; Kaminski et al., 2009).

We showed in our experiment, that dogs pay attention to the perception of humans and that they use this information when choosing between two forbidden food items. We found differences between four genetically distinct breed groups, as well as between three groups based on their working style. Dogs categorized as ancient type and hunting dog type, as well as the independently working style and family style groups, performed similarly and seemed to be more attentive to their owners' perception than the dogs from the other groups. This difference cannot be explained by a different proportion of dogs being active in dog sports, which seems to make the dogs less likely to pay attention on the owner's perception. Breed differences play an important role in several communicative tasks; however, it is not clear yet how it is influencing the dogs' performance in a specific task. Further studies are necessary for a better understanding of the relevance of the dog's breed when testing them in different communicative tasks.

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