universität wien

MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

„Eavesdropping in pet dogs (*Canis lupus familiaris*) in relation to experience in years with humans"

verfasst von / submitted by

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angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien, 2022 / Vienna 2022

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	UA 066 878
Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet:	Masterstudium Verhaltens-, Neuro- und Kognitionsbiologie
Betreut von / Supervisor:	Mag. Dr. Friederike Range

Abstract

Cooperation is important for survival and reputation formation is a key component of group-living animals that can facilitate cooperation. Reputations can be formed through direct experience or indirect experience, also called eavesdropping. Eavesdropping is an information-gathering process by observing third-party interactions. Dogs (*Canis lupus familiaris)* are a good model species for studying eavesdropping as they can cooperate with humans. Based on the mixed results of previous studies, we aimed to investigate whether pet dogs can form indirect reputations in a food-giving situation using human-animal interactions, where a generous person feeds the dog and a selfish person does not. We also tested whether older dogs with more life experience might be more likely to eavesdrop than younger dogs. We found no support for our hypothesis that dogs can form reputations about unfamiliar humans in a food-giving situation by eavesdropping, nor were there any differences between age groups. Our study shows that indirect reputation formation is a cognitively demanding skill and therefore further studies need to be conducted to reach a general conclusion.

Key words: Indirect reputation formation, domestic dog, eavesdropping, age effect

Zusammenfassung

Kooperation ist essenziell für das Überleben für Tiere, die in Gruppen leben. Die Reputationsbildung über andere Gruppenmitglieder ist eine Schlüsselkomponente, die die Zusammenarbeit erleichtern kann. Die Reputation eines Individuums kann durch direkte Erfahrung oder indirekte Erfahrung, auch „Eavesdropping“ genannt, gebildet werden. „Eavesdropping“ ist ein Prozess der Informationsgewinnung durch Beobachtung und Lauschen der Interaktionen Dritter. Hunde (Canis lupus familiaris) sind eine gute Modellart für die Untersuchung von „Eavesdropping", da sie mit dem Menschen in enger Kooperation stehen. Wir untersuchten, ob Haushunde diese Fähigkeit der indirekte Reputationsbildung besitzen, indem sie eine Mensch-Tier-Interaktionen beobachteten, bei denen eine großzügige Person einen Artgenossen fütterte und eine egoistische Person dies nicht tat. Wir testeten auch, ob ältere Hunde mit mehr Lebenserfahrung eher lauschen/beobachten als jüngere Hunde. Wir fanden keine signifikanten Ergebnisse für unsere Hypothese, dass Hunde sich indirekt Informationen beschaffen können. Die Hunde wählten die großzügige Person daher nicht öfters als die egoistische und es gab keine Unterschiede zwischen den Altersgruppen. Unsere Studie zeigt, dass „Eavesdropping“ eine kognitiv anspruchsvolle Fähigkeit ist und daher weitere Studien durchgeführt werden müssen, um zu einer allgemeinen Schlussfolgerung zu gelangen.

Schlüsselwörter: Indirekte Reputationsbildung, Haushund, Eavesdropping, lauschen, Alterseffekt

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1. Introduction

1.1 Cooperation

Living in social groups and forming bonds can be beneficial for animals, as a large group offers protection and they can work together in the search for food (Melis et al., 2010; Abdai & Miklósi, 2016). Especially in these socially living groups, cooperation can arise (Hare, Brown, Williamson & Tomasello, 2002). Cooperation is a collective action and without working together they would not gain a common benefit (Lindenfors, 2017). It can occur within species but also between different species (Melis & Semmann, 2010). An example for cooperation is the joint hunting of wolves (*Canis lupus*). Their hunting success increases with the size of the group; therefore, they can take down larger prey if they hunt together (Abdai & Miklósi, 2016; MacNulty, 2014).

1.2 Reputation formation

To cooperate efficiently, one should choose a partner carefully, e.g., by taking the reputation of others into account (Russell et al., 2008). Reputation is the knowledge of an individual's expected behaviour based on his past behaviour (Russell et al., 2008) and can create a positive or a negative social evaluation (Abdai & Miklósi, 2016). For example, individuals who work together to gain access to food that they could not get alone may be evaluated as socially positive, gain a good reputation, and may receive help frequently (Melis et al., 2010). This suggests that reputation may play an important role in the evolution of cooperative behaviour (Russell et al., 2008; Melis et al., 2010) and it is important to recognize which group members are helpful. In this way, it is beneficial for group members to choose a partner with a good reputation, thus increasing the likelihood that they will be able to work together successfully and share the benefits. (Abdai & Miklósi, 2016).

Reputation can be formed through direct or indirect experience, known as eavesdropping (Chijiiwa et al., 2015; Abdai & Miklósi, 2016). Direct reputation (first-hand experience) is the most accurate predictor of an individual's future behaviour as it is based on direct experience with that individual (Subiaul et al., 2008). Eavesdropping is the ability to gather relevant information through indirect experience, e.g., by observing an interaction between two individuals (third-hand experience) (Parejo et al., 2007), and can promote an individual's direct fitness with little effort and risk (Brügger et al., 2021; Bonnie & Earley, 2006; Freidin et al., 2013). However, they still have to invest some energy because they have to recognise and remember the individual's behaviour. This may be cognitively more difficult than first-hand experience (Subiaul et al., 2008).

Eavesdropping has been investigated in human children, e.g., Hamlin et al. (2007) tested whether 6–10-month-old children can evaluate individuals in their behaviour towards others. They saw a helper (prosocial) who supported a character climb up a hill, a hinderer (antisocial) who pushed the character down, and a neutral character walking up and down the hill without any interaction. The children preferred the helper over the hinderer and the neutral individual (Abdai & Miklósi, 2016; Hamlin et al.,

2007). This suggests that the ability to form reputations of others is innate, because the young children had little experience with other people and few opportunities to observe third-party interactions to form reputations of others. However, in a study by Herrmann et al. (2013), 2.5-year-old children observed an experimenter interacting with a mean and a nice person. Afterwards the children could approach a person and they did not show a preference for either person. The result of this study might have been limited because the children only saw 2 trials, and the indirect reputation formation could not be consolidated (Herrmann et al., 2013). Furthermore, 3-year-olds can differentiate who they help based on their past moral behaviour. Vaish et al. (2010) tested 3-year-olds who observed one adult harming another person, one helping the person, and a third being neutral. The children then helped the prosocial person and the neutral person more often than the harming person. In another experiment, 3-year-old children observed a person who unintentionally harmed another person and a person who intentionally harmed another person, as well as a neutral person. The children then helped the harming adult less often than the neutral person and the person who unintentionally harmed them. This shows that indirect information gathering has a great influence on children's prosocial behaviour at a very early age.

1.3 Studies in non-human primates

Since humans are closely related to monkeys and apes, and studies have been conducted on cooperative behaviour and reputation formation learning in humans (Hamlin et al. 2007; Herman et al., 2013), this phenomenon has also been tested with non-human primates to elucidate whether this ability was present in our common ancestor or whether humans developed this skill after the human-ape split. In a study by Russell et al. (2008), chimpanzees (*Pan troglodytes*) observed a human beggar who begged for some grapes from a nice and a mean person; the nice person gave him some, but the mean person did not and, in contrary, hit him if the beggar grabbed the grapes by himself. Afterwards, the nice and the mean person sat side by side and they measured how much time the chimpanzees spent close to the two people and they found that chimpanzees spent more time close to the nice than to the mean person. Also, Subiaul et al. (2008) tested seven chimpanzees, which observed one unfamiliar human giving food to a familiar human and another unfamiliar human refusing to give food. Then the selfish and the generous donor stood opposite the chimpanzee with two pieces of food in their hands. The chimpanzee could then gesture at one of the two. The generous donor gave him the pieces of food and the selfish donor pretended to eat them himself. They developed a preference for the generous donor after more than 32 trials (Subiaul et al., 2008). In another study from Herrmann et al. (2013), chimpanzees, orangutans (*Pongo pymaeus)* and bonobos (*Pan paniscus*) were tested on eavesdropping in a food-giving situation. The experiment included a generous person who gave the subject food and a selfish person who did not. Afterwards the subject could choose between the two experimenters. Orangutans and chimpanzees chose the generous person more often, while bonobos did not choose the generous person over the selfish person (Herrmann et al., 2013). Taken together, the results of these studies suggest that non-human primates possess the ability to eavesdrop.

1.4 Studies in domesticated animals

Since human interactions are often used for studies on eavesdropping on non-human apes, there is a lack of ecological validity because non-human primates do not interact with humans in their natural setting and they are not dependent on humans for social information. Therefore, it is better to explore eavesdropping with domesticated animals since they are very closely connected to the human environment, so social information about humans might be more relevant to them (Silver et al., 2021). Trösch et al. (2020) investigated eavesdropping in domestic horses (*Equus caballus*). The horses were shown two videos, in one they saw an unfamiliar experimenter grooming an unfamiliar horse, which led to positive emotions and behaviour of the actor horse, e.g., ears oriented backwards. The second video showed a veterinary act on an unfamiliar horse, which led to negative emotions of the actor horse, e.g., backed away. Afterwards, the experimenters from the videos tried to get the horse's attention. The horse touched the negative experimenter more often than the positive experimenter. The results are surprising as they expected the horse to touch the positive experimenter more often. The authors suggested that these results could be interpreted as appeasement behaviour from the horse towards the negative experimenter (Trösch et al., 2020). Chijiiwa et al. (2021) studied whether cats (*Felis silvestris catus*) preferred to take food from a person who helped their owner or from someone who did not. However, cats showed neither a preference for the helper or for the non-helper. A possible explanation for this result is that cats have not been domesticated for cooperation with humans, unlike dogs *(Canis lupus familaris)* (Chijiiwa et al., 2021).

Dogs are an interesting model species to study eavesdropping because they are highly cooperative with humans (Range et al., 2019) and since eavesdropping may facilitate cooperation, it is plausible that dogs may posses this ability. There are several studies on eavesdropping in a food-giving situation in dogs, e.g., in Kundey et al. (2011), dogs watched two unfamiliar human demonstrators – one gives a treat to a human recipient and the other withheld the treat. Then, the dogs could choose one of the two people for taking a treat. They preferred the treat-giving human. In another study (Marshall-Pescini et al., 2011), dogs observed two humans eating from a bowl and a human who begged them both for the food. The generous one gave the beggar some food and the selfish one did not. In the test phase, the dog was allowed to move freely in the room to interact with the two experimenters for 20 seconds and the duration of the interactions with each experimenter was analysed. The dogs had a clear preference for the generous person, which suggests that they used third-party interactions to gain information about how the experimenters would behave in a food-sharing situation.

A study by Freidin et al. (2013) showed similar results. Dogs observed a beggar receiving food from two humans and the beggar's reaction was positive to one person and negative to the other. They found that dogs significantly preferred the person who received a positive reaction from the beggar. However, the experimenters always stood on the same side of the room between the observation phase and the test phase, so a side preference could not be excluded, and indeed, the dogs chose randomly when the experimenters swapped positions. Therefore, this study showed that dogs preferred the side

where the generous interaction happened rather than the generous human regardless of her position, known as local enhancement. Another study from Nitzschner et al. (2014) found results to support local enhancement. They replicated Marshall-Pescini et al.'s (2011) study and tested for local enhancement by having the experimenters stay on the same side of the room between the observation phase and the test phase for half of the sample and swap sides for the other half of the sample. The dogs chose the generous experimenter more often when they stayed on the same side than when they changed sides. These results demonstrate that controlling for local enhancement is important when designing studies on eavesdropping in animals.

Other studies have investigated eavesdropping using a helping situation, e.g., in Chijiiwa et al. (2015), dogs watched their owners who tried to open a box and asked for help from an actor. In the helper condition, the actor helped the owner to open the box, and in the non-helper condition, the actor turned away and refused to help. Apart from the actor who sat on one side of the owner, there was also a neutral person sitting opposite the owner. When the observations were completed, the actor and the neutral person each offered the dog a piece of food. The choices of the dogs were arbitrary in the helper condition, but in the non-helper condition they significantly avoided contact with the non-helper. Avoiding a person who has behaved negatively towards the owner shows that eavesdropping may indeed have taken place.

Jim et al. (2020) combined a helping situation with a food-sharing situation and tested for local enhancement. The dogs watched an experimenter ask for help to open a box with food inside from a helpful and an unhelpful human, then the dogs were given an opportunity to interact with the box, which was locked. When they were unable to retrieve the food from the box, they first looked at the person who was previously helpful towards another person. However, when the experimenters swapped sides, there was no significant difference whether the dogs looked at the helpful or the unhelpful human. This suggests that the dogs chose the helpful partner based on their location rather than forming a helpful reputation of the partner. In the choice test, the dogs were free to approach an experimenter who gave them a treat. The results showed that dogs chose the helpful and unhelpful experimenter at chance level regardless of whether the partners stood on the same side or swapped positions.

Silver et al. (2021) tested if there is a difference between trained and untrained pet dogs' ability to eavesdrop. The experimental setup was similar to Chijiiwa et al. (2015) – dogs observed an experimenter who tried to get an object; the helpful person gave him the object and the unhelpful person threw it away. Afterwards, the dogs could choose from which of the two people they wanted a treat. The untrained pet dogs had no preference, but the trained ones significantly chose the prosocial helper. A possible explanation could be that training changes the bond between dog and owner and dogs become more sensitive to people and even more attentive to human cues (Silver et al., 2021). However, they did not control for local enhancement so therefore the dogs might have simply favoured the side of the prosocial person.

All these studies used human interactions, but it could be better to look at human-animal interactions because dogs can likely learn better from a conspecific than a human. In Nitzschner et al. (2012), the dogs observed a familiar dog that was treated nicely by one person and ignored by another. The dogs were then allowed to interact with both humans. However, there was no preference for the nice or the ignoring human, possibly due to a lack of food as motivation. Rooney and Bradshaw (2006) observed dogs watching a human-dog game interaction, both competing for an object. Afterwards, the dog could choose freely with whom to interact. If the interaction was playful (indicated by a signal), the dog tended to approach the winner of the interaction. If it was not playful, the dog tended to approach more slowly, regardless of who won or lost. This suggests that the dogs received information from the third-party interaction and interacted more with the playful individuals.

1.5 Age and life experience

Through the domestication process, dogs have adapted to the human environment and enabled them to form close relationships with humans, such as by being able to follow human cues and cooperating with humans (Cooper et al., 2003). The domestication hypothesis states that the behavioural adaptations of dogs are a direct consequence of genetic changes, independent of environment or the experience with humans (Udell et al., 2010). The Two-Stage Hypothesis from Udell et al. (2010), however, postulates that domestication alone is not the sole reason why dogs cooperate with humans. Pet dogs that live in a family home have a strong affiliative bond with humans, whereas shelter dogs have little contact with humans (Duranton et al., 2016). Udell et al. (2008) tested pet dogs and shelter dogs in a human pointing experiment. An experimenter stood between two containers and pointed to one of the containers. If the dogs chose this container they got a treat, if not the experimenter was left in a neutral position. Pet dogs performed better than shelter dogs perhaps due to their greater experience with humans (Udell et al., 2008).

Passalacqua et al. (2011) tested whether dogs with more life experience directed gaze behaviour towards humans for longer than puppies and whether they used gaze as a request for help. Dogs were tested at 2 months, 4.5 months and as adults. The dogs had to manipulate a plastic container and were given food. Older dogs looked at the human more often and for longer than puppies, and they gazed back and forth between the human and the container more often, which is considered an indicator of intentional communication because they refer to the object. The results show that age/life experience has an effect on how dogs interact with humans.

Jim et al. (2022) tested hand-reared and pack-living dogs and wolves from the Wolf Science Centre for indirect reputation formation. They tested whether wolves and dogs have the ability to eavesdrop at all and whether dogs have inherited this ability or whether it has developed through the domestication process. In their experiment, the wolves observed two humans interacting with a demonstration dog, one feeding the dog and the other refusing to feed it. The wolves were then allowed to choose one of the two partners, but the results were not significant. However, since the literature on

pet dogs also shows positive results on eavesdropping, we instead compare pet dogs of different ages in our experiment. The life experience of WSC dogs and wolves and that of pet dogs differ significantly from each other, since pet dogs have more experience with humans, they might also be more likely to have the ability to eavesdrop.

1.6 Study aim and hypothesis

Based on the mixed results of the previous studies, we aimed at investigating whether pet dogs can form reputations in a begging situation using human-animal interactions. We decided on this methodical approach because the begging situation involving food is more relevant for dogs than a helping situation. In our experiment, a dog watched two humans interact with another dog – the generous person fed the demonstrator dog and the selfish person did not feed the demonstrator dog, then the subject had to choose with whom to interact. We hypothesised that dogs can eavesdrop and predicted that they will prefer the generous partner over the selfish partner after observing them interacting with another dog in a third-party interaction. Additionally, we tested whether age and the life experience influenced the eavesdropping ability of the dogs. Therefore, we predicted that age will have an effect on the dogs' ability to eavesdrop – specifically, older dogs will more often choose the generous person over the selfish person compared to younger dogs due to older dogs having more experience in interactions with humans.

2. Material and Methods

2.1. Ethical statement

Ethical approval was obtained from the Institutional Ethics and Animal Welfare Committee from the University of Veterinary Medicine Vienna in accordance with GSP guidelines and national legislation (ETK-023/02/2021). All involved employees (e.g., partners and experimenters) and dog owners signed a data protection statement in which they consented to be filmed and photographed and agreed to be mentioned in any publication.

2.2. Study subjects

We recruited 44 dogs and during the study 4 dogs dropped out, so the sample included 40 dogs (20 females and 20 males). We recruited dogs that were older than one year and no breeds were excluded (Table 1). The subjects were recruited from social media and a database of owners who volunteered to participate in behavioural studies at the Clever Dog Lab, University of Veterinary Medicine Vienna. The owners and dogs participated voluntarily in the study and if the dogs were not motivated, the experiment was stopped and postponed to another day.

Table 1: List of dogs that participated in the study. Dogs in red dropped out of the study.

Name	Sex	Breed	Age	Age category	Group
Dunni	F	Miniature Pinscher	1	Early adulthood	Experimental
Gandalf	M	Andalusian Hound	1		
Crash	M	Australian Shepherd	2		
Daytona	F	Australian Shepherd	2		
Holly	F	Rottweiler	2		
Pauli	M	Labrador	2		
Ravenna	F	American Staffordshire Terrier	3		
Ajani	F	Mix	4	Middle age and late adulthood	
Cody	M	Siberian Husky	4		
Chivas	M	Siberian Husky	5		
Lilu	F	Mix	5		
Lenny	M	Canarian Warren Hound	6		
Bailey	F	Pitbull Terrier	7		
Capper	M	Andalusian Hound	7		
Fee	F	Rottweiler	7		
Aaron	M	Labrador	8	Senior and geriatric	
Helena	F	Poodle	9		

Sally	F	Mix	9		
Snoopy1	M	Shih Tzu	10		
Amy	F	Border Collie	11		
Monty	M	Border Collie	11		
Snoopy2	M	Beagle	12		
Lenny2	M	Border Collie	12		
Jazzie	F	Labrador	1	Early adulthood	Control
Spaiky	M	Cane Corso	1		
Franzi	F	Rottweiler	2		
Timo	M	Mix	2		
Zazu	F	Miniature Pinscher	2		
Anni	F	Labrador	3		
Asha	F	Rhodesian Ridgeback	4	Middle age and late adulthood	
Sixtus	M	Petit Brabancon	4		
Django	M	American Staffordshire Terrier	5		
Ellis	F	Portuguese Water Dog	5		
Kiki	F	Mix	6		
Ozzy	M	Labrador	6		
Graf Aidan	M	Irish Setter	6		
Rusty	M	Mix	7		
Lilly	F	Miniature Pinscher	8	Senior and geriatric	
Alois	M	Mix	9		

Fiona	F	Rhodesian Ridgeback	9		
Shari	F	Rottweiler	9		
Jolie	F	Mix	10		
Mozart	M	Labrador	11		
Ultimo	M	Border Collie	11		

2.3. Experimental design

There were two groups (10 females and 10 males per group) with a between-subjects design:

1. Experimental: The subject observed the partners interacting with a demonstrator dog to test for eavesdropping.
2. Control: The subject observed the partners performing the same actions as in the experimental group to a "ghost" demonstrator dog. This was conducted to discern whether the dogs' responses are due to the partner observing the social interaction between partner and demonstrator in the experimental condition because they eavesdropped or whether the partners' actions *per se* were sufficient to allow a discrimination between them.

We used a matched sample of dogs to get a similar range of dogs regarding age and sex in the experimental and the control condition, i.e., 10 male and 10 female dogs with a range of ages in each condition. We classified them in the following age categories: 1-3 years as 'Early adulthood', 4-7 years as 'Middle age and late adulthood', and 8-12 years as 'Senior and geriatric'. We used these age categories based on the previous literature – Champagain et al. (2020) categorised early adulthood as 1-3 years and middle age as 4-6 years and Chapagain et al. (2017) categorised late adulthood as 6-7 years, senior as 8-10 years and geriatric as 10+ years. We categorised the age groups like this so we could be sure that our sample size was as balanced as possible (11 dogs in early adulthood, 15 in middle age + late adulthood, 14 in senior + geriatric, see Table 1).

In total, 10 unfamiliar women acted as the partners throughout the study. The pair of partners remained stable for one subject. One partner was dressed in white and the other was dressed in black clothes, and their roles and colour of clothes were randomised and counterbalanced between-subjects. For each subject, the colour of the clothes and the role of the partners remained the same in session 1 and 2 so that they would not get confused and could distinguish the roles better (i.e., fixed within-subjects). During the experiment, the generous and selfish partners carried dark hip bags with small pieces of sausage inside.

There were two demonstrator dogs that interacted with the partners in the observation phase for the experimental group – a male dog (Jasper, 11 years, Labradoodle) acted as the demonstrator for female subjects and a female dog (Emmi, 4 years, Labrador) acted as the demonstrator for male subjects. We chose demonstrator dogs of the opposite sex so that the subject would be less distracted by dominance behaviour.

2.4. Experimental setup

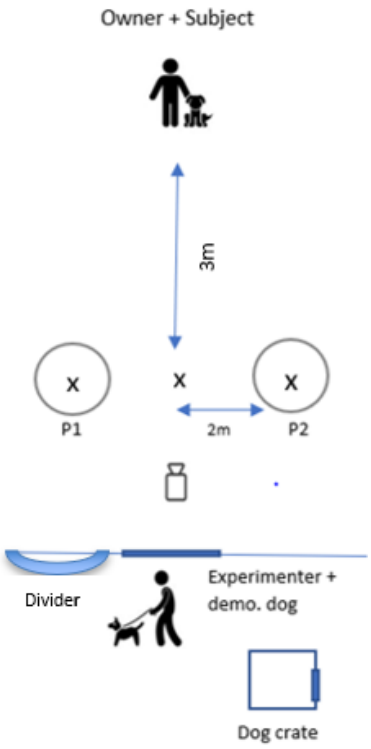

Figure 1: Schematic drawing of the experimental setup

The experiment took place in a fenced outdoor test enclosure of the Clever Dog Lab (Figure 1). The experiment was held in all weather conditions and water for the dogs was always available. We spray painted the grass to mark where people had to stand during the experiment. P1 and P2 were marked 2m from the middle point in the centre of the enclosure (Figure 2). A circle with a radius of 50cm was marked around P1 and P2. A chair was placed 3m away and perpendicular from the middle point, where the owner sat during the experiment. One camera (GoPro Hero 4 Black) was placed on a tripod in the enclosure and filmed the whole experiment. A divider was placed behind the fence. The demonstrator dog and the partners stood behind the divider when they were outside the enclosure, so that the subject could not see them and could not be distracted by them. The experimenter stood outside of the enclosure next to the divider. A crate was placed outside the area where the demonstrator dog was briefly placed during the test phase so as not to disturb the subject.

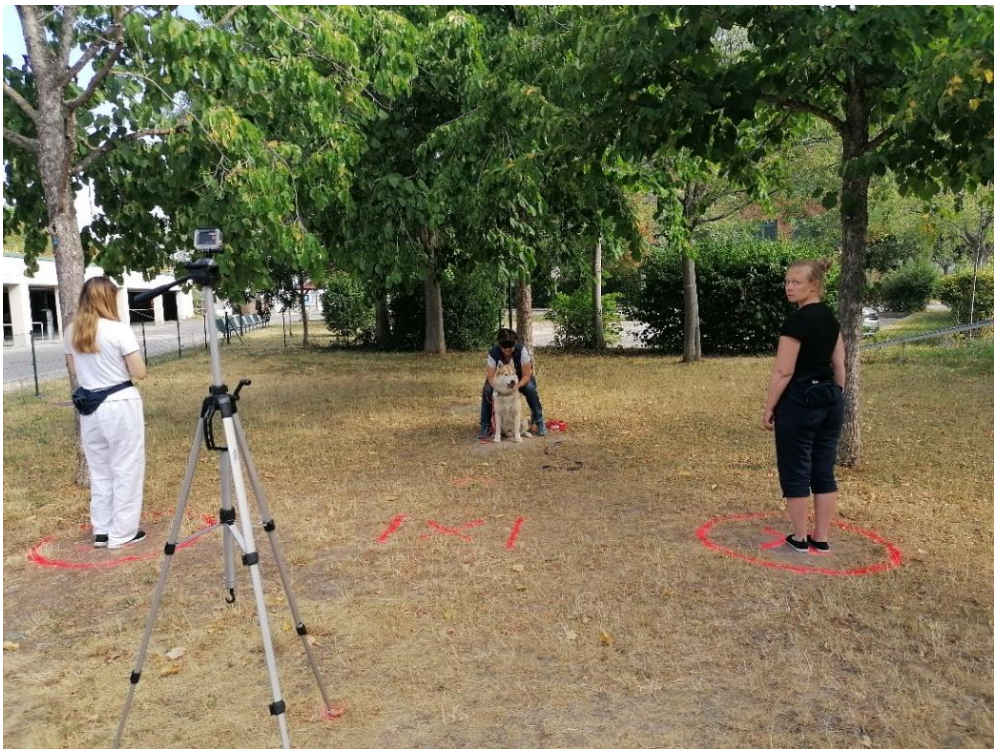

Figure 2: Experimental set up. P1(left), middle point, P2 (right), chair with owner and subject

2.5. Experimental procedure

The study was conducted from May until August 2021. The whole experiment consisted of two sessions (Figure 3). The duration of each session was approximately 10-15 minutes.

Session 1

Session 1 was divided into 4 phases:

1. Habituation: Before the test, the subject got to know the demonstrator dog in a short social walk around the Vetmeduni campus (5-10 minutes) to ensure that the dogs tolerated each other and could focus on the experiment later. If they did not tolerate each other, the dog did not participate in the experiment. After the habituation phase, the subject and the owner entered the test enclosure and the subject could explore it freely for five minutes. The demonstrator dog was placed in a crate behind the divider outside the test enclosure so the subject could not see the demonstrator dog.

2. Baseline: The owner sat on the chair and held his/her dog by the collar. The owner was blindfolded so he/she could not influence the dog throughout the study. The partners entered the test enclosure and stood on P1 and P2 (their positions were randomised and counterbalanced across subjects), each holding a piece of sausage in their hand. The experimenter stood outside the test enclosure and called "okay" to indicate the owner to release the dog and started the stopwatch. If the dog placed a paw into the circle marked around the partner and looked at the partner, it was defined as a choice and the partner fed the dog. Immediately afterwards, the non-chosen partner caught the dog's attention and fed it so that it could not develop a preference for a partner. If the dog did not choose either partner within one minute, it was defined as a "no-choice" response. After this single trial, the experimenter called "stop" and the owner called the dog back, held it by the collar and the partners left the test enclosure and stood behind the divider.

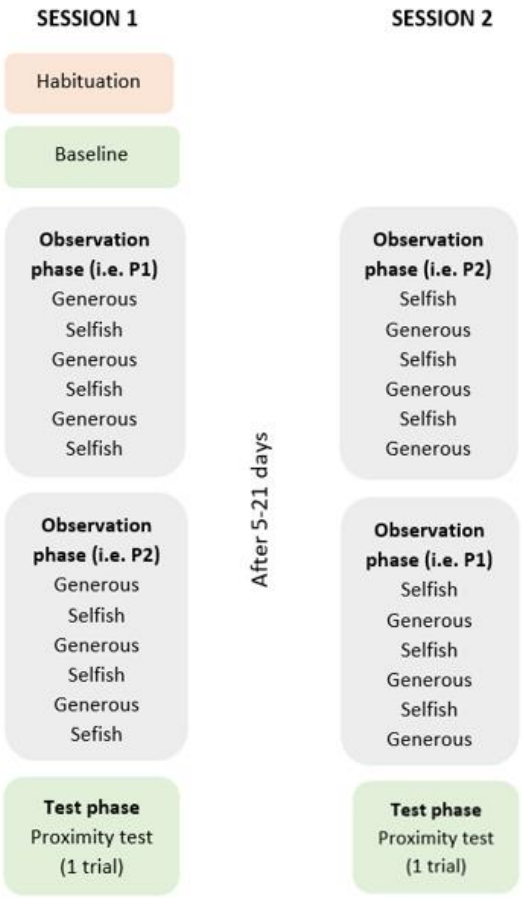

Figure 3: Overview of experimental procedure

3. Observation phase: In the experimental group, the experimenter entered the test enclosure with the demonstrator dog on a leash and stood on P1 or P2 (counterbalanced across subjects, e.g., P1). Then, one partner entered the test enclosure and stood on the opposite position (e.g., P2). The experimenter walked up to the middle point with the demonstrator dog and the subject observed one of the following scenarios, depending on the partner:
   - **Generous*:*** The generous partner raised the piece of sausage up in her hand and said: "Here you go!/Du kannst es haben!" in a friendly tone and fed the demonstrator dog (Figure 4a).
   - **Selfish:** The selfish partner raised the piece of sausage up in her hand and said: "You can't have it/Du kriegst es nicht!" in an unfriendly tone, turned her back to the dog and folded her arms, keeping the food in her hand (Figure 4b).

Figure 4a: Generous role

Figure 4b: Selfish role

After the interaction, the experimenter and the demonstrator dog walked back to P1 and the partner left the test enclosure and stood behind the divider. Then, the second partner entered the enclosure, walked to P2, and interacted with the demonstrator dog. The order of the partners was counterbalanced across subjects. Each partner interacted with the demonstrator three times in an alternate order (e.g., selfish, generous, selfish, generous, selfish, generous). Afterwards, the experimenter and demonstrator dog swapped sides with the partners and the procedure was repeated (i.e., the experimenter and demonstrator stood on P2 and the partners stood on P1 and interacted with the demonstrator dog three more times in an alternate order). Therefore, the demonstrator interacted with each partner three times per side and six times in total. Afterwards, the experimenter and the demonstrator dog left the test enclosure and the demonstrator dog was placed in the crate. The experimenter gave the demonstrator dog a treat so it remained quiet and would not disrupt the test.

In the control group, the exact same scenario took place as the experimental group, only without the demonstrator dog. Thus, the generous partner raised the piece of sausage up in her hand and said: “Here you go!/Du kannst es haben!” and pretended to feed a dog. The partner held her hand out with the food for three seconds and then left the enclosure. The selfish partner also raised the piece of sausage up in her hand and said: “You can’t have it!/Du kriegst es nicht!” in an unfriendly tone, turned her back to the dog and folded her arms, keeping the food in her hand. The selfish partner also waited three seconds

before leaving the enclosure because in the experimental group, it took the experimenter and the demonstrator dog a few seconds to walk back to P1 before the partners left the enclosure.

4. Test phase: There was a single proximity test. The partners entered the test enclosure and stood on P1 and P2 (their positions were randomised and counterbalanced across subjects). The experimenter stood outside the test enclosure called "okay" to indicate to the owner to release the dog and started the stopwatch. The dog was free to roam in the enclosure for one minute. The partners did not interact with the dog and kept looking straight ahead and did not make eye contact with him/her (Figure 5). After one minute, the experimenter called "stop" and the owner called the dog back and held it by the collar and the partners left the test enclosure and the session was over.

Figure 5: Proximity test

Session 2

This session took place 5-21 days after Session 1 and consisted of the observation phase and the test phase. The procedure was identical but the order of the partners was counterbalanced and the positions of the experimenter and the demonstrator dog and the partners were the opposite of Session 1 in the observation phase (i.e., the experimenter and demonstrator dog stood on P2 and the generous partner started and stood on P1 first) and the partners stood on the opposite side of Session 1 in the test phase (Figure 3).

2.6. Behavioural analysis

We coded the video footage of the whole enclosure from the GoPro. The videos were uploaded to Loopy by Loopbio and each video was coded with Loopy. We coded the duration of time the subject spent close to the generous and the selfish partner separately in the test. The trial started from the moment the experimenter called “okay!” and ended when she called “stop!” In addition to proximity, we recorded the dog’s first choice towards the generous or selfish partner (see Table 2 for definitions).

Table 2: Definitions of coded behaviours

Behaviour	**Definition**
Proximity to partner (Duration)	○ When the dog’s paw is within/on the circle; when the dog is touching the partner; if the dog is looking at the partner and steps out of the circle and still looking at the partner
Choice (Event)	○ When the dog’s paw is within the circle + looking at the generous/selfish partner

2.7. Statistical Analysis

The statistical analyses were conducted with R (version 4.0.3; R Core Team 2020). The confidence in the “Model estimation” was determined using the confint.merMod function (method = "boot") of the R package "lme4". We tested for collinearity by determining the Variance Inflation Factors (VIF) for a standard linear model without the random effects using the function vif of the R package "car" (v3.0.12). Random slopes were identified, and Roger Mundry (2020) kindly provided functions which evaluated the model stability.

To test if dogs spent more time close to the generous partner in the experimental or in the control condition, we used a Generalized Linear Model (GLM) with beta error distribution and logit link function (function glmmTMB of the R package “glmmTMB”). The test predictors were *condition* (factor with two levels: experimental or control), *age category* (factor with three levels: early adulthood, middle age and late adulthood, senior and geriatric) and *trial* (factor with two levels: proximity test 1 and proximity test 2), which was z-transformed. Therefore, the full model included an interaction between trial × condition × age category. Subject ID was included as a random intercept and z-transformed trial as a random slope within subject ID. The response variable was *proportion of time* they spent in proximity to the generous experimenter (values above 0.5 indicate bias towards generous person and values below 0.5 indicate bias towards the selfish person). We compared the full model to the null model, which lacked the interaction between trial × condition × age category. Model stability was good (see the range of estimates in Table 3) and there was no collinearity (max VIF = 1.003).

We also analyzed if dogs preferred the generous person over the selfish person by comparing their first approach in the baseline, proximity test 1 and proximity test 2. To test this, we used a Generalized Linear Mixed-Effects Model (GLMM) with binomial error structure and logit link function (function glmer of the R package "lme4"). The test predictors were *trial* (factor with three levels: baseline, proximity test 1 and proximity test 2) *condition* (factor with two levels: experimental or control) and *a*ge *category* (factor with three levels: early adulthood, middle age and late adulthood, senior and geriatric). Subject ID was included as a random intercept and trial was manually dummy coded and centred and added as a random slope within subject ID. The response variable was *choice* to approach the generous or selfish partner. To facilitate convergence, we changed the optimizer used by the glmer function to "bobyqa" (Jacobson, n.d.). A correlation of random intercept and the slope was excluded because it was essentially estimated to be 1, indicating that it is not identifiable (Matuschek et al., 2017). The full model was then compared to the null model, which lacked the interaction between trial × condition × age category. The model was considered extremely unstable (see range of estimates in Table 4) and there was no collinearity (max VIF = 1.003).

3. Results

We did a likelihood ratio test of the beta regression model and compared the full model with the null model and it shows that the interaction between *trial x condition x age category* had no significant effect on the proportion of time, so whether the dogs spent more time out of a minute with the generous or with the selfish person ($\chi^2 = 9.305$, $df = 11$, $p = .594$) (Table 3, Figure 6).

Table 3: Results of the beta regression model [estimates, standard errors, and confidence intervals (CIs)], z-value, p-value and the estimates obtained for model stability (minimum and maximum).

Terms	Estimate	SE	95% Cl		z	p	Min	Max
			Upper	Lower				
Intercept	0.17574	0.37887	0.8835658	-0.5389282	0.464	0.643	-0.333	0.515
Group: experimental	0.26259	0.49722	1.2556638	-0.7453146	0.528	0.597	-0.051	0.822
Age category: middle	0.02888	0.48482	0.9094053	-0.8932562	0.060	0.953	-0.293	0.572
Age category: old	-0.44417	0.48973	0.5141409	-1.4903747	-0.907	0.364	-0.775	0.080
Z-transformed trial	-0.32393	0.47870	0.6329284	-1.3090250	-0.677	0.499	-0.440	-0.181
Group: experimental x Age category: middle	-0.45236	0.68643	0.8678060	-1.8123409	-0.659	0.510	-1.137	-0.132
Group: experimental x	-0.27926	0.66472	1.1019364	-1.6753514	-0.420	0.674	-0.869	0.022

Age category: old								
Group: experimental x z.trial	0.11783	0.63573	1.4874628	-1.1852646	0.185	0.853	-0.215	0.573
Age category: middle x z.trial	-0.44913	0.61227	0.7739301	-1.7167359	-0.734	0.463	-0.676	-0.307
Age category: old x z.trial	0.66798	0.62490	1.9228563	-0.5971877	1.069	0.285	0.257	1.044
Group: experimental x Age category: middle x z.trial	0.54454	0.84449	2.2603428	-1.2140107	0.645	0.519	0.085	0.870
Group: experimental x Age category: old x z.trial	-0.25984	0.84333	1.5581948	-2.0539067	-0.308	0.758	-0.727	0.133

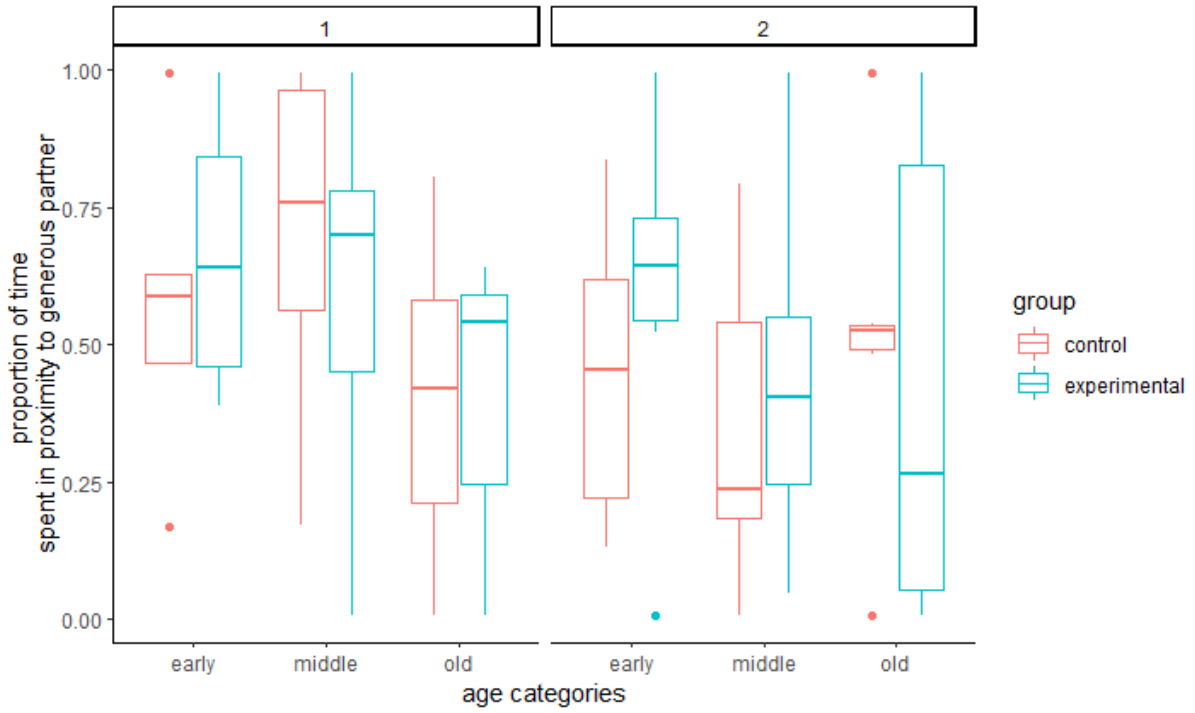

Figure 6: Proportion if time spent in proximity (within 1 minute) to the generous partner in relation to the age categories (early, middle, old dogs) in trials 1 and 2 of the proximity tests. the colours show the condition (control=red, experimental =blue)

The likelihood ratio test of the binomial model comparing the full to null model shows that the interaction between *trial x condition x age category* had no significant effect on the choice, so whether the generous partner was chosen more than the selfish (χ^2 = 16.843, *df* = 17, *p* = .465) (Table 4).

Table 4: Results of the binomial model [estimates, standard errors, and confidence intervals (CIs)], z-value, p-value, and the estimates obtained for model stability (minimum and maximum)

Terms	Estimate	SE	95% Cl		z	p	Min	Max
			Upper	Lower				
Intercept	1.709	1.385	15.680	-3.617	1.234	0.217	1.253	18.491
Group: experimental	-3.686	2.051	-1.134	-35.579	-1.798	0.072	-20.371	-3.108
Age category: middle	-1.691	1.633	-22.577	-35.579	-1.035	0.301	-18.486	-1.201
Age category: old	-0.548	1.661	14.982	-7.324	-0.330	0.741	-17.391	0.311
trialf1	-3.412	1.966	-0.893	-30.461	-1.735	0.083	-19.791	-2.565
trialf2	-2.435	2.260	2.659	-27.353	-1.077	0.281	-18.495	-1.210
Age category: middle x Group: experimental	2.509	2.333	26.796	-11.900	1.076	0.282	1.514	19.263
Age category: old x Group: experimental	2.890	2.401	33.871	-5.217	1.204	0.229	1.858	19.604
Age category: middle x trialf1	1.046	2.253	13.621	-18.591	0.464	0.643	-15.789	17.542
Age category: old x trialf1	2.613	2.260	32.183	-5.409	1.156	0.248	1.760	19.015
Age category: middle x trialf2	3.303	2.886	45.151	-3.716	1.144	0.253	1.920	19.336
Age category: old x trialf2	-0.049	2.805	13.521	-36.074	-0.017	0.986	-1.687	16.110
Group: experimental x trialf1	4.498	2.570	41.886	-3.230	1.750	0.080	3.366	21.146
Group: experimental x trialf2	3.184	2.987	34.651	-7.152	1.066	0.286	1.623	19.993
Age category: middle x Group: experimental x trialf1	-1.846	3.059	22.745	-25.791	-0.603	0.546	-18.408	15.077
Age category: old x Group: experimental x trialf1	-3.699	3.038	9.986	-42.071	-1.218	0.223	-20.305	-2.464
Age category: middle x Group:experimental x trialf2	-3.421	3.867	20.702	-44.039	-0.885	0.376	-20.273	-1.803
Age category: old x Group: experimental x trialf2	-1.574	3.831	22.640	-27.393	-0.411	0.681	-18.317	0.110

Since the results were non-significant, we looked at whether the dogs had a colour and/or side bias, so we conducted exact binomial tests. We counted the number of times the dogs chose the partner wearing black as ‘success’ and we counted the number of times the dogs chose the partner standing on the left as ‘success’. The results showed that 19 out of 40 dogs had a side bias for the left and 4 out of 40 dogs had a colour preference for black (Table 5). Since almost half of the sample had a side bias, we ran the

models again excluding the side biased dogs to analyse whether the dogs that did not have a side bias eavesdropped or not.

Table 5: Results of the exact binomial test for colour and side bias [subject, number of trials colour, number of successes, number of successes side, p-values]

		Colour bias		Side bias	
Subject	**Number of trials**	**Number of successes (black)**	***P***	**Number of successes (left)**	***p***
Aaron	24	13	.839	2	**< .001**
Aidan	27	18	.122	13	1
Ajani	27	14	1	9	.122
Alois	25	13	1	2	**< .001**
Amy	24	17	.064	18	**.023**
Asha	27	15	.701	13	1
Bailey	27	8	.052	8	.052
Capper	27	11	.442	8	.052
Chivas	19	10	1	3	**.004**
Cody	26	9	.169	12	.845
Crash	25	14	.690	3	**< .001**
Daytona	24	16	.152	7	.064
Django	24	11	.839	6	**.023**
Dunni	26	9	.169	4	**.001**
Ellis	27	12	.701	7	**.019**
Fiona	26	16	.327	4	**.001**
Franzi	26	13	1	7	**.029**
Gandalf	27	10	.248	14	1
Helena	27	13	1	0	**< .001**
Holly	27	16	.442	21	**.006**
Jazzie	27	17	.248	4	**< .001**
Jolie	26	12	.845	18	.076
Kiki	20	15	**.041**	11	.824
Lenny	26	7	**.029**	11	.557
Lilly	27	11	.442	6	**.006**
Lilu	27	10	.248	18	.122
Monty	27	10	.248	11	.442
Mozart	21	7	.804	13	.383
Ozzy	27	14	1	26	**< .001**
Ravenna	27	13	1	12	.701
Rusty	27	9	.122	6	**.006**
Sally	26	11	.557	14	.845
Shari	21	7	**.029**	13	.383
Sixtus	25	14	.690	10	.424

Snoopy1	25	9	.230	4	**.001**
Snoopy2	25	7	**.043**	10	.424
Spaiky	23	12	1	14	.405
Timo	22	9	.524	17	**.017**
Ultimo	26	14	.845	24	< **.001**
Zazu	26	6	**.009**	10	.327

The likelihood ratio test of the non-side bias dogs beta regression model comparing the full to null model shows that the interaction between *trial x condition x age category* had no significant effect on the proportion of time, so whether the dogs spent more time out of a minute with the generous or with the selfish person (χ^2 = 15.129, *df* = 11, p = .177). The model stability was unstable and there was no collinearity (max VIF = 1.002) (Table 6).

Table 6: Results of the non-side bias dogs beta regression model [estimates, standard errors, and confidence intervals (CIs)], z-value, p-value and the estimates obtained for model stability (minimum and maximum)

Terms	**Estimate**	**SE**	**95% Cl**		**z**	**p**	**Min**	**Max**
			Upper	Lower				
Intercept	-0.68278	0.49793	0.3288329	-1.8204832 4	-1.371	0.170 30	-1.441	0.129
Group: experimental	1.49416	0.64438	3.1051101	0.3342927 3	2.319	0.020 41	0.708	2.279
Age category: middle	1.22607	0.63031	2.71855480	0.0472453 3	1.945	0.051 75	0.440	2.011
Age category: old	0.07902	0.63534	1.6314451	-1.2788480 9	0.124	0.901 02	-0.819	0.813
z.trial	0.095 52	0.80036	1.7274231	-1.6124206 2	0.119	0.905 00	-0.080	0.271
Age category: middle x Group: experimental	-2.31168	0.81991	-0.8218236	-4.3976969 2	-2.819	0.004 81	-3.139	-1.565
Age category: old x Group: experimental	-1.69602	0.86045	-0.1462738	-3.8656829 8	-1.971	0.048 71	-2.485	-0.889

Groupexperimentalxz.trial	0.39106	1.03097	2.7366428	-1.67939380	0.379	0.70446	-0.145	0.899
Age category: middle x z.trial	-0.08528	0.99525	1.8578793	-2.35312063	-0.086	0.93171	-0.245	0.107
Age category: old x z.trial	0.74663	1.03433	3.1871461	-1.53535511	0.722	0.47039	-0.891	2.683
Age category: middle x Group: experimental x z.trial	-1.03175	1.28299	1.7335395	-3.81414935	-0.804	0.42129	-1.518	-0.483
Age category: old x Group: experimental x z.trial	-1.85490	1.39332	0.9320071	-5.36193046	-1.331	0.18310	-3.885	-0.294

The likelihood ratio test of the non-side bias dogs binomial model comparing the full to null model shows that the interaction between *trial x condition x age category* had no significant effect on the choice, so whether the generous partner was chosen more than the selfish (χ^2 = 25.509, *df* = 17, *p* = .084). The model stability was extremely unstable and there was no collinearity (max VIF = 1.005) (Table 7).

Table 7: Results of the non-side bias dogs binomial model [estimates, standard errors, and confidence intervals (CIs)], z-value, p-value and the estimates obtained for model stability (minimum and maximum)

Terms	**Estimate**	**SE**	**95% Cl**		**z**	**p**	**Min**	**Max**
			Upper	Lower				
Intercept	0.000	1.414	8.275	-9.107	0.000	1.000	-19.566	19.566
Group: experimental	-19.480	9807.435	-10.928	-26.915	-0.002	0.998	-39.046	0.086
Age category: middle	-1.099	1.826	7.937	-16.903	-0.602	0.547	-20.665	18.467
Age category: old	19.566	10236.633	25.996	10.383	0.002	0.998	0.000	39.132
trialf1	-19.459	11885.443	-9.954	-26.747	-0.002	0.999	-39.132	0.000

trialf2	-19.459	11885.439	-12.745	-26.744	-0.002	0.999	-39.132	0.000
Age category: middle x Group: experimental	19.886	9807.435	30.439	10.961	0.002	0.998	0.320	40.241
Age category: old x Group: experimental	-0.779	14176.545	4.599	-10.598	0.000	1.000	-20.360	18.787
Age category: middle x trialf1	19.459	11885.443	27.440	8.693	0.001	0.999	0.000	39.132
Age category: old x trialf1	19.459	18730.752	28.087	9.687	0.001	0.999	0.000	39.132
Age category: middle x trialf2	19.459	11885.439	27.933	12.393	0.002	0.999	0.000	40.220
Age category: old x trialf2	-19.673	20080.720	-12.401	-29.546	-0.001	0.999	-39.132	0.000
Group: experimental x trialf1	39.633	15409.397	49.668	31.240	0.003	0.998	20.174	59.306
Group: experimental x trialf2	19.459	18265.684	27.820	11.670	0.001	0.999	0.000	39.132
Age category: middle x Group: experimental x trialf1	-39.633	15409.397	-30.069	-52.141	-0.003	0.998	-59.306	-20.174
Age category: old x Group: experimental x trialf1	-39.633	21143.009	-29.275	-49.721	-0.002	0.999	-80.902	-20.174
Age category: middle x Group:experimental x trialf2	-18.766	18265.684	-8.557	-26.266	-0.001	0.999	-39.526	0.693
Age category: old x Group: experimental x trialf2	19.673	24405.058	27.086	11.607	0.001	0.999	-6.783	40.932

4. Discussion

4.1. General Discussion

The aim of this study was to test indirect reputation formation in pet dogs. Our main finding is that dogs did not choose to approach or spend more time near the generous partner significantly more often than the selfish one. Thus, our hypothesis that dogs can form indirect reputations about unfamiliar humans in a food-giving situation was refuted. Due to the close coexistence of dogs with humans, they might be able to adapt to the communication of humans, especially in cooperative aspects (Bräuer et al., 2006; Reid, 2009; quoted from Piotti et al., 2017). Dogs therefore rely on humans, often independently of the human's intentions, and for this reason, dogs might have spent time with the selfish partner as well (Piotti et al., 2017).

The generally negative results of eavesdropping studies may refer to the fact that dogs rely on humans taking the leadership and frequently making decisions for the dog. Therefore, especially pet dogs might have no reason to eavesdrop on a conspecific. Perhaps the study would have been different for free-ranging dogs, as they are more dependent on eavesdropping, e.g. due to a need to observe their environment constantly and closely in order to survive and looking for helpful cooperation's instead of wasting their energy begging a selfish human.

Another reason why they did not eavesdrop could be that the dogs could not distinguish between the two individuals or there were too few trials to form a reputation. In this study, the dogs observed 6 interactions per partner and 12 interactions in total. Before this experiment, a pilot study was carried out to test the number of repetitions that would lead to a consolidation of dogs choosing the generous person, which showed that dogs significantly preferred the generous person after 6-10 trials. However, the pilot dogs interacted directly with the partners, so it might not have been suitable for indirect reputation formation, as this is more cognitively complex than direct reputation formation. In Kundey et al. (2011), the dogs had 10 demonstrations in the observation phase and they demonstrated eavesdropping, but there was no control for local enhancement. Unlike other studies, we control for local enhancement and had more than 10 demonstrations, so it does not seem to be too few trials. Furthermore, if we had increased the number of demonstrations to more than 12, it could have led to a decrease in the dogs' attention. Since the subjects were attentive in the observation phase, we argue that the number of demonstrations was appropriate, and a lack of attention was not the reason for finding no positive results.

It could be that the test dogs only paid attention to the presence of the new dog and less to the experiment and the humans' actions. In Rooney and Bradshaw's (2006) study, they used familiar demonstration dogs for each dog, either dogs that lived with them or dogs that they saw regularly. With the social walk at the beginning of our experiment, we wanted the dogs to become familiar with the demonstration dog so that their focus was not entirely on the demonstration dog, but on the generous and selfish person and their actions.

A dog may show a preference for one partner through acoustic, olfactory and visual cues, even if both partners are unknown to the dog. It is difficult to make the appearance, the smell and the way of moving completely the same for all partners. Therefore, our partners did not smile at the dogs, did not speak to them, did not make eye contact with the test dog and behaved as similar as possible. Of course, since the partners both had sausages in their bags, they could have preferred both partners equally.

Since we did not find evidence of eavesdropping, we investigated whether the dogs might have had a colour or/and a side preference. There was no colour bias but some of the eavesdropping studies found that dogs tended to prefer one side rather than a person (Freidin et al., 2013; Nitzschner et al., 2014; Jim et al., 2020). We tried to prevent a side bias by counterbalancing the sides, but we still found 19 out of 20 dogs showed a side bias for the left side. After excluding the side biased dogs, we repeated the analysis, but the results were still not significant. A possible reason for the side preference could be that it was shadier on the left side because there was a tree next to it, providing protection from sun and rain.

The experiment took place in an outdoor area, so there were more disruptive factors than in the indoor lab rooms. Disturbance by noise was often present, e.g., cars or other dogs and owners passing by the test enclosure. In addition, dogs were sometimes distracted by scent marked areas of previous dogs. We conducted the study in the summer and in all weather conditions, so it was sometimes very warm or raining. Thus, in future studies, a quieter outdoor area or an indoor area in the Clever Dog Lab would be preferable.

4.2. Age effect

The second aim of the study was to test dogs of different ages to examine whether age/experience influenced their eavesdropping ability. We investigated whether the dogs' ability to eavesdrop correlated with age, as we hypothesized that older dogs have more life experience and therefore may choose the generous person over the selfish person after observing the third-party interactions. We compared dogs of different ages but found no significant difference. For the young dogs, it may indeed be due to lack of experience with humans, dogs and the new situation that they did not eavesdrop (Passalacqua et al. 2011; Udell et al. 2010). The results for the middle-aged dogs could be explained by a decline in attention, because Chapagain et al. (2020) showed that attention decreases in dogs from 6 years on. We observed that the older dogs (8-12 years, senior + geriatric) sometimes tended to lie down next to the owner instead of choosing a partner. Motivation and food motivation can also decrease due to poorer physical condition in old dogs (Chapagain et al., 2020). All dogs were healthy but maybe for older dogs it was physically too strenuous, especially when the weather conditions were bad.

Additionally, the aging process is different between breeds. For example, in Great Danes, 5 years is already considered old, whereas Beagles can live up to 15 years. (Urfer et al., 2011). Researchers suspect that the shorter lifespan is due to the rapid growth of large dog breeds (Jimenez et al., 2018). The dog breeds in our study had strikingly large differences in size, which is why age boundaries are

fluid. In future studies, the distinction between age groups could be redesigned to reflect this correlation between age and size, e.g. focus on certain dog breeds.

Our sample size was not too small, but for future studies, an even larger sample size according to the age categories would be interesting. An increase in the number of test dogs could yield different results, e.g., Marshall-Pescini et al. (2011) used 100 dogs.

4.3. Improvements of prior studies

Although the generous person was preferred to the selfish person in previous food-giving experiments (Kundey et al., 2011, Marshall-Pescini et al., 2011), our study adds to the negative results on eavesdropping using human-animal interactions in dogs (Nitzschner et al., 2012) and other animals, such as cats (Chijiiwa et al. (2021), horses (Trösch et al., 2020), Asian elephants (*Elephas maximus*) (Jim et al., 2021) and some non-human primates (Herrmann et al., 2013). The mixed results of the eavesdropping studies can also be attributed to the different methodological uses, for example whether it is a food-giving situation (Kundey et al., 2011; Marshall-Pescini et al., 2011; Freidin et al., 2013) or a helping situation (Chijiiwa et al., 2015; Silver et al., 2021) and whether the dog observes a human-human (Kundey et al., 2011; Freidin et al., 2013; Chijiiwa et al., 2015; Jim et al., 2020; Silver et al., 2021) or a human-animal interaction (Nitzschner et al., 2012). Most eavesdropping studies use human-human interactions, so we used human-dog interactions in our experiment. We argue that animal-human interactions are better to study eavesdropping because it is possible that they can relate to the dog in the third-party interaction more easily than watching two humans interacting, so our results may be more valid than previous studies that used human-human interactions. Another difference to the previous studies on indirect reputation formation could be that our experiment was conducted outside, while most of the other studies took place indoors. The experiment by Nitzschner et. al. (2012) took place in a laboratory and the test dog was in a plexiglass enclosure, from where he could observe the interaction between dog and human. For future studies, indoor rooms with such a set-up would be helpful.

4.4. Outlook to the future and Conclusion

The study may have had a different result if we had taken the training background of the dogs into account. There are dogs that are challenged by various training courses (therapy dog training, etc.), clicker training, agility, calm training, and other dogs that are not challenged as much. Trained dogs need to work closely with humans, and this changes the extend of experience a dog has with human beings (Silver et al., 2021). Therefore, based on our negative results, perhaps it is not solely the age that is decisive for the interaction between dogs and humans, but rather the type and intensity of the experience with humans. Dogs that work closely with humans may improve in the way they cooperate with them and are thus more able to eavesdrop.

In addition, it would be interesting to test pet and shelter dogs to see if there is a difference in their ability to eavesdrop based on their different experiences with people. Shelter dogs are more dependent

on eavesdropping because they tend to have had more negative experiences with people and as a result are more careful about whom they trust. Therefore, shelter dogs should actually be more likely to eavesdrop than pet dogs, which generally have more positive experiences with people (Cimarelli et al., 2021).

In conclusion, there are only few studies about eavesdropping of pet dogs between a conspecific and a human in a food-giving situation and our study is the first to test additionally age and life experience (Udell et al., 2010). However, we found no evidence that pet dogs distinguished between a generous and selfish partner after observing third-party interactions. Eavesdropping is a topic that needs further research as it is a cognitively complex ability, which helps us to understand what experiences animals use to make their decisions and whether these experiences really depend on the age of the dogs. In any case, the group of pet dogs is well suited for the topic as they work together with humans. Our study perhaps closes another gap in the research on eavesdropping and offers new methodological approaches for future studies. Even though we did not find significant results, it is important to continue research in this area, as it increases our understanding of the cooperative mechanisms animals have for survival strategies.

5. Acknowledgements

I would like to thank my co-supervisor Dr. Hoi-Lam Jim for being there whenever questions arose at any time of the day, for her assistance with the data collection and for the many helpful tips and improvements to the thesis.
Many thanks to Prof. Dr. Friederike Range for giving me the chance to work on such an exciting topic and for the meetings in which we were able to clarify many questions.
I would like to thank my study partner Eva Martinelli, she studied reputation formation and we recruited dogs and conducted the experiment together, which was really worth it to be able to exchange ideas all the time.
A big thank goes to Zsanett Györi, Sari Komulainen, Klara Schulmeister, Agnes Tiefling and Michaela Tost, who acted as the best partners ever and were very flexible and invested a lot of time. Without them, I would not have been able to conduct this study. Of course I would like to thank all the participants and dogs who supported me by taking part in the study. Further, I thank Mayte Martinez for statistical advice.
I would also like to thank my mother, who always made everything possible and supported me.
Finally, I would like to thank our demonstration dogs Emmi and Jasper and their owners. The two had a positive influence on everyone involved and were an enrichment!

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