MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

"Do dogs use self-experience in a perspective-taking task?"

verfasst von / submitted by

Veronika Francesca Szewczak, BSc

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

Master of Science (MSc)

Wien, 2023 / Vienna, 2023

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:	Univ.-Prof. Mag. Dr. Thomas Bugnyar

Acknowledgements

I would like to thank a few people who helped me completing this project.

To my supervisors, thank you for your guidance and support throughout the steps of this work. I would like to express my deepest appreciation to Dr.rer.nat. Christoph Völter, who guided me with his expertise through the entire experimental, statistical and writing phases. I would also like to express my sincere gratitude to Univ.-Prof. Dr.rer.nat. Ludwig Huber and the whole unit of Comparative Cognition at the Messerli Research Institute of the University of Veterinary Medicine in Vienna, which provided support with administration, IT and workshop. To Lucrezia Lonardo (MSc) and Univ.-Prof. Mag. Dr. Thomas Bugnyar, thank you for supervising my work and your support.

I want to thank the Clever Dog Lab (University of Veterinary Medicine of Vienna) and the people behind it for providing a wonderful environment for testing and recruiting dogs and their owners. Here, I specifically want to thank Mag. rer. nat. Karin Bayer for always being available whenever I needed assistance in the Lab and for always helping in any way she could.

To the dog owners, thank you for participating in my study.

To my family and friends, both inside and outside the lab, thank you for always supporting me. Your encouragement has been a constant source of motivation.

And to my partner Valère, thank you for looking after me and always being by my side through every step of this project.

Abstract

The present study investigated whether dogs (*Canis familiaris*) can use their own experience with novel barriers to infer if someone else can or cannot see through the same barriers. Two pre-tests were conducted to select dogs that first, refrained from eating forbidden food when the experimenter was present and second, attempted to "steal" forbidden food when the experimenter was absent. Dogs that passed the pre-tests were familiarized with the properties of two screens, one opaque and one transparent, each inserted in a wooden tunnel. In the final test, the experimenter simultaneously placed two treats in front of each tunnel. The experimenter was able to see the previously forbidden food through one of two differently coloured tunnels but not through the other one. The dogs, which were no longer able to see the screens directly nor the experimenter that hid behind a visual barrier, then had to make the choice in front of which tunnel (opaque or transparent) they wanted to steal the forbidden treat first. The tested dogs did not show a preference to steal the treats behind the opaque tunnel more often than behind the transparent tunnel. However, dogs approached the food more slowly when the experimenter was present than when the experimenter left the room, even though they could not see them behind the visual barrier. Furthermore, the study identified breed differences, with terriers (FCI-3) showing a significant preference for the opaque tunnel, independent of the experimenter's presence, compared to the other tested breeds.

Keywords: Canine cognition, Canis familiaris, visual perspective-taking, theory of mind

Zusammenfassung

In der vorliegenden Studie wurde untersucht, ob Hunde (*Canis familiaris*) die visuelle Perspektive von anderen einnehmen können. Zunächst wurden Pretests durchgeführt, in denen Hunde ausgewählt wurden, die erstens, kein verbotenes Futter fressen, wenn die Versuchsleiterin anwesend ist und zweitens, das Futter "stehlen", wenn die Versuchsleiterin nach dem Verbot den Raum verlässt. Daraufhin wurden die Hunde mit den Eigenschaften von zwei Tunneln (durchsichtig/undurchsichtig) vertraut gemacht. Im finalen Experiment legte die Versuchsleiterin jeweils ein Leckerli vor beide Tunnel, verbat den Hunden diese zu essen und versteckte sich dann hinter einen undurchsichtigen Vorhang. Die Hunde mussten sich entscheiden, vor welchem (undurchsichtigen oder durchsichtigen) Tunnel sie das Leckerli zuerst stehlen. Die Hypothese war, dass die Hunde basierend auf ihren eigenen Erfahrungen mit den Tunneln darauf schließen können, was der Versuchsleiter sehen kann und was nicht. Die Ergebnisse zeigen keine signifikante Präferenz der Hunde die Leckerlis hinter dem undurchsichtigen Tunnel häufiger zu stehlen als hinter dem durchsichtigen Tunnel, unabhängig von der Anwesenheit der Versuchsleiterin. Wenn die Versuchsleiterin hinter dem Vorhang war, näherten sich die Hunde dem Futter allerdings langsamer an, obwohl die Hunde sie nicht sehen konnten. Darüber hinaus wurden Rasseunterschiede festgestellt. Terrier zeigten, unabhängig von der Anwesenheit der Versuchsleiterin, eine signifikante Präferenz das Leckerli hinter dem undurchsichtigen Tunnel zu stehlen. Die Ergebnisse dieser Studie deuten darauf hin, dass Hunde visuelle Hinweise benötigen, um die Perspektive eines anderen einzunehmen. Weitere Forschung ist erforderlich, um die Fähigkeit von Hunden, insbesondere von Terriern, zur Perspektivenübernahme vollständig zu verstehen.

Table of Contents

Acknowledgements 2
Abstract 3
Zusammenfassung 4
Table of Contents 5
Introduction 6
Material and Methods 11
  Ethical approvement, Pre-registration and owner consent 11
  Subjects 11
  Experimental Set-up 14
  Experimental Procedure 14
  Behavioural Analysis 23
  Statistical Analysis 24
Results 26
  Confirmatory Analysis 26
  Exploratory Analysis 31
Discussion 35
References 41

Introduction

Theory of Mind (ToM) is the ability to ascribe mental states, including desires and beliefs, to others (Premack & Woodruff, 1978). Understanding that others' minds and mental states differ from one's own and the capacity to infer what others are thinking allows humans to interpret, predict and even manipulate others' behaviour. In the past, researchers employed non-verbal tasks with preverbal children and non-human animals to investigate the ability to explain others behaviour in terms of mental states. Until this day, it is still debated whether this ability is uniquely human or shared with other animals (see reviews: Krupenye & Call, 2019; Perner & Roessler, 2012).

The term "Theory of mind" has been defined as an umbrella term, because it cannot be defined by an unitary cognitive process, but can rather be decomposed into unique, much simpler socio-cognitive skills, one of them being visual perspective taking (VPT) (Huber & Lonardo, 2023). VPT can be classified into two levels: level 1 and level 2 perspective taking. Level 1 (VPT-1) refers to the understanding of what is within someone's line-of-sight, including which objects are visible and which are hidden, while level 2 (VPT-2) involves mentally adopting another's point of view and understanding how the world appears from the other subjects' unique perspective (Flavell et al., 1986).

Inferring and exploiting what other individuals can or cannot see can offer numerous advantages for animals living in social groups - It allows individuals to gather relevant information from their conspecifics. For example, by following the gaze of others, individuals may come across important resources like food, predators and/or other group mates. Moreover, knowing what others can or cannot see can be particularly beneficial in situations where food resources are scarce and the competition is high, especially for subordinates who have to weigh the risks of approaching and taking food in the presence of dominant individuals (Bräuer et al., 2004).

Whether non-human animals can take up the perspective of someone other and therefore recognize their level of knowledge has been a debated topic in the study of animal cognition for the past years. A highly investigated element of perspective-taking is the understanding of what others can see from their perspective, particularly if this differs from the individual's own perspective. Additionally, researchers are curious if animals can use the ability to take another's' perspective to predict what others know and what they might do in the future (Bräuer et al., 2004; Catala et al., 2017). Numerous studies indicated that not only chimpanzees but also other animals that live in social complex environments, both primates and non-primates, show understanding of others' perception, like for example lemurs (Sandel et al., 2011), dolphins (Xitco et al., 2004), ravens (Bugnyar & Heinrich, 2005) and goats (Kaminski et al., 2006).

In the past 30 years, the interest in studying canine cognition has increased due to numerous factors. Studies with dogs (*Canis familiaris)* have been done to understand cognition in other species, including humans, and fundamental areas of animal behaviour such as memory, foraging and social learning, since dogs have proven to show extraordinary cognitive capabilities and are easily "accessible" for studies due to the large public interest in understanding the "man's best friend" (Bensky, 2013).

Many studies have been conducted in order to investigate in the VPT- abilities in dogs. A first step to address the question is to consider whether they are attentive to the human's attentional state (Bräuer, 2014). In various studies it has been found that dogs indeed behave differently depending on the humans' attentional state. For example, in the study by Call et al. (2003) it has been shown that dogs, that were forbidden by a human to consume a piece of food, held back from taking it when the human was watching them, but took it more readily when the human closed their eyes, turned their back or were distracted with other activities. These results have been repeatedly found in other experiments using the same context (Schwab & Huber, 2006) as well as in other, more cooperative, contexts (Gácsi et al., 2004; Virányi et al., 2004). The findings of these studies do suggest that dogs indeed show sensitivity to human attention, but one explanation for this sensitivity might be that they simply react to certain stimuli, such as the visibility of the eyes, when assessing whether the human is attentive or not. In other words, dogs might have developed behaviour - reading skills to succeed in these tasks.

With more complex experimental approaches, a number of studies tried to identify the limits of dogs' perspective-taking abilities across different experimental contexts (Catala et al., 2017; Heberlein et al., 2017; Kaminski et al., 2009; Maginnity & Grace, 2014). For example, in a study by Bräuer et al. (2004), the authors placed forbidden food behind three different kinds of barriers with different properties. One barrier was small, one was big, and the third one was big but had a see-through window in the middle. The authors found that dogs showed sensitivity to the effectiveness of a barrier in obstructing a human's vision, therefore they were more likely to consume forbidden food when the barrier was larger, compared to when it was smaller or see-through.

In a study by Kaminski et al. (2009) it has been investigated whether dogs could take the visual perspective of a human when it differed from their own one. Here, the dogs were encouraged to cooperate with the human experimenter. Two toys were placed respectively on the dog's side of two barriers so that the dog could see both. One barrier was opaque, while the other one was transparent. In the experimental condition, a human sat on the opposite side of the barriers, therefore they could only see the toy behind the transparent barrier. The experimenter commanded the dog to 'Bring it here!', without designating either toy in any way. They also performed a "Back Turned control", in which the experimenter sat on the opposite side with their back turned so that they could see neither toy. Lastly, they performed the "Same Side control", in which the experimenter sat on the same side as the dog, hence they could see both toys. The results of this study showed that dogs preferred to approach the toy behind the transparent barrier in the experimental significantly more as compared to the back turned and the same side control conditions. Conversely, in a more competitive context, an study by Kaminski et al. (2013) showed that dogs stole significantly more food when it was dark compared to when it was bright in a room in which a human that forbid them to take the food was present.

Heberlein and colleagues (2017) found that there are genetic and working style differences among various dog breeds, which might explain the variation in performance of dogs across studies. In their study they applied a food competition paradigm similar to that of Bräuer et al. (2004). They stated that breed differences and ontogeny might affect the performance of dogs in such tasks, because 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. They found that dogs that were assigned to the independently working style group and family style group preferred to eat first the food item behind an opaque screen than behind a transparent screen, while the dogs assigned to the cooperative working style group chose randomly.

Although all these studies provide compelling evidence that dogs have knowledge of what humans can see, the difficulty here is to differentiate between the complex skill of mind-reading and simpler cognitive processes, such as behaviour-reading, which involves interpreting observable characteristics, such as the gaze or attentive state of others (Catala et al., 2017; Huber & Lonardo, 2023).

A strong test for disentangling mentalizing from simple behaviour-reading skills, called the "goggles test", was proposed by C. Heyes in 1998. Here, the author proposed to explore if chimpanzees can project their own experience of seeing or not seeing through a novel surface onto others. Karg, Schmelz, Call and Tomasello (2015) implemented the paradigm with chimpanzees and tested whether they could use self-experience to infer what another individual can see using a competitive context. The competitive context was established by the experimenter taking the food away when the chimpanzee tried to grab it. After that, the experimenter sat opposite the chimpanzee with food in boxes right and left to their side. Those two boxes had different visual properties, either an opaque or a transparent lid, with which the chimpanzees got familiarized. During the final test, the lids were closed and now they looked identical from the chimpanzees' perspective (i.e., the chimpanzees could only distinguish the opaque and transparent lid based on what they had seen in the familiarisation phase). The chimpanzee could choose to steal food from one of the boxes. Interestingly, they found that the animals had a preference to reach into the box with the opaque lid that hid the approaching hand significantly more often than into the transparent one. This supports the notion that chimpanzees are able to use their own experience to infer from which box the experimenter would not see their approaching hand. Moreover, a recent study has shown that several great apes are capable of making distinct anticipations regarding the action of an agent even in the absence of any behavioural cues and relying only on their own past experiences of perceptual access (Kano et al., 2019).

The aim of the present study was to explore whether pet dogs could draw inferences about the visual perception of others based on their own experience with novel barriers. To investigate this, a competitive context - dogs being prohibited from taking a piece of food by the experimenter, similar to the study on chimpanzees by Karg and colleagues (2015) - was established. Because of the results from Heberlein et al. (2017) the study focused on testing dogs that belonged to the independent or family working style group.

Two pre-tests were conducted to select for dogs that met the criteria for the actual test. The first pre-test aimed to select dogs that refrained from eating forbidden food when the experimenter was present. Dogs that tried to take the food anyway had it taken away by the experimenter, therefore the dogs learned to not take the food when the experimenter was present. The second pre-test aimed to select dogs that attempted to "steal" forbidden food when the experimenter was absent. Dogs that successfully passed the pre-tests experienced two novel barriers, which had different see-through-properties (one opaque, the other transparent). In the final test, the experimenter was able to see the forbidden food through one of two differently coloured tunnels (containing a transparent screen), but not through the other one (containing an opaque screen). The dogs were no longer able to see the screens directly nor the experimenter that hid behind a visual barrier at the opposite end of the tunnels.

A previous study with a very similar setup has already been conducted (Putnik, 2022). Here, the dogs were also familiarized with the same two novel barriers as in the present study. What differed from the present study is that they measured the dogs' gaze-following response when the experimenter looked at a target object (a bucket) either through the tunnel containing the opaque screen or through the tunnel containing the transparent screen. They found that the dogs followed the experimenters' gaze when the experimenter looked at the target object through the tunnels. However, the dogs' gaze congruent looking times, first looks and first choices to the target object did not depend on whether the experimenter looked into the transparent or the opaque tunnel. Therefore, the results of this study did not provide evidence that dogs would project their own knowledge onto others – at least in the context of gaze following.

With the present study, the goal was to make the perspective of the human experimenter more relevant to the dogs by establishing a competitive context. The hypothesis was that dogs are able to use their own previous experience with the tunnels to infer what the experimenter can and cannot see. The prediction was that dogs would be more inclined to steal the treat that was placed behind the opaque screen first because they would understand that the experimenter would not be able to see them steal the treat there.

Material and Methods

Ethical approvement, Pre-registration and owner consent

The ethical application for this study was submitted and approved by the institutional ethics and animal welfare committee at the University of Veterinary Medicine Vienna in accordance with Good Scientific Practice guidelines and national legislation (ethics approval number: ETK-162/09/2022). Furthermore, this study was preregistered prior to data collection on the OSF platform (Völter et al., 2022).

The owners and their dogs were recruited by directly contacting dog-owners using an internal database of the Clever Dog Lab (University of Veterinary Medicine of Vienna) or/and by an online announcement. The entire experimental procedure was non-invasive. Prior to testing, the dog owners signed two documents declaring that their participation in this study was entirely voluntarily, giving their general consent to participate and agreeing that the acquired data and information might get used for future scientific purposes.

Subjects

All subjects that participated in the experiment were privately owned dogs (*Canis lupus familiaris*). Overall, 83 dogs initially took part in the experiment, of which 23 dogs were excluded during or after completing the study (see Section excluded subjects), leaving 60 dogs (33 females, 27 males) for analysis.

All tested dogs were purebred and registered as FCI breeds. Following the classification of dog breeds based on their working style from Heberlein (2017), only breeds that belonged to the “independent working style” and “family-style” working groups, or breeds that were within the same FCI-group/FCI-section as them, participated in this study, with one dog being an exception because of experimental error. The age of the animals ranged from 11 to 114 months (see Table 1).

Before starting the experiment, a power analysis, with a target sample size of 50-80 dog, was performed. Assumptions were based on the previous study by Heberlein et al. (2017), indicating mean proportions of choices in the control condition (0.5) and experimental condition (0.65 or 0.7). A total of 1000 datasets were simulated with two trials per condition and varying subject numbers which were then fitted with a generalized linear mixed model. The analysis revealed an 80% power with a sample size of 60 dogs. Testing was continued until the predetermined sample size of 60 dogs was reached, excluding any dogs that failed to meet the inclusion criteria.

During the study, 23 dogs had to be excluded from the sample. Out of these, 19 dogs were disqualified from the experimental procedure either because of failure to meet the inclusion criteria or because they exhibited a significant stress response during the pre-tests (Pre-test I(a): n=7, Pre-test II: n=7, Pre-test I(b): n=4). Additionally, one dog had to be excluded due to experimental error during the pre-test phase. After analysing the video-recordings, four dogs needed to be excluded from the sample due to experimental error (n=3) and the owner's influence on the dog's behaviour (n=1) after completing the experiment. In total, the excluded dogs accounted for 27.7% of the total sample size.

Table 1: Name, sex (f=female, m=male), age (in months), breed, FCI-group and group based on working style in reference to Heberlein (2017) of included dogs.

Name	Sex	Age	Breed	FCI-Group	Working-style
Aoife	f	119	Irish Glenn of Imaal Terrier	3	Independent-working style
Aziz	m	141	Hovawart	2	Family-style
Balou	m	68	French Bulldog	9	Family-style
Bärli	m	93	Irish Glenn of Imaal Terrier	3	Independent-working style
Chewie	m	62	Bernese Mountain Dog	2	Family-style
Chomsky	m	84	Rottweiler	2	/
Cory	f	107	Whippet	10	Independent-working style
Diego	m	64	Border Terrier	3	Independent-working style
Django	m	89	American Staffordshire Terrier	3	Family-style
Dorli	f	22	Wirehaired Dachshund	4	Independent-working style
Duana	f	109	Irish Glenn of Imaal Terrier	3	Independent-working style
Ellie	f	54	Shih Tzu	9	Family-style
Finja	f	81	Maltese	9	Family-style
Finne-Faiblhe	f	49	Irish Glenn of Imaal Terrier	3	Independent-working style
Flee	m	47	Siberian Husky	5	Independent-working style
Hero	m	17	Whippet	10	Independent-working style
Jamie	m	50	Greyhound	10	Independent-working style
Jay	m	78	French Bulldog	9	Family-style
Kira	f	15	Siberian Husky	5	Independent-working style
Kukie	f	16	Border Terrier	3	Independent-working style
Lillybet	f	90	Samoyeder	5	Independent-working style
Lilo	f	73	Whippet	10	Independent-working style
Lilo	f	17	Miniature Poodle	9	Family-style
Loki	m	89	Greater Swiss Mountain Dog	2	Family-style
Lottie	f	56	Parson Russel Terrier	3	Independent-working style
Lucy	f	90	Chihuahua	9	Family-style
Lucy	f	16	Miniature Poodle	9	Family-style
Ludwig	m	52	American Staffordshire Terrier	3	Family-style
Madlain	f	85	Border Terrier	3	Independent-working style
Mado	f	47	West Highland White Terrier	3	Independent-working style
Maggy	f	69	Whippet	10	Independent-working style
Maya	f	29	Hovawart	2	Family-style
Maybe	f	55	Parson Russel Terrier	3	Independent-working style
Milo	m	27	Staffordshire Bull Terrier	3	Family-style
Mimi	f	74	Havaneser	9	Family-style
Monty	f	108	Border Terrier	3	Independent-working style
Nele	f	18	Löwchen	9	Family-style
Nuki	m	14	Whippet	10	Independent-working style
Oscar	m	24	Havaneser	9	Family-style
Oscar	m	54	Miniature Bull Terrier	3	Family-style
Paul	m	123	Whippet	10	Independent-working style
Peggy	f	105	Bernese Mountain Dog	2	Family-style
Pepper	f	58	Parson Russel Terrier	3	Independent-working style
Poppy	f	17	MinitureDachshound	4	Independent-working style
Principessa	f	20	Whippet	10	Independent-working style
Quintus	m	75	Hovawart	2	Family-style
Ragnar	m	60	Bedlington Terrier	3	Independent-working style
Rose	m	20	Foxterrier	3	Independent-working style
Rudi	m	21	Parson Russel Terrier	3	Independent-working style
Sammy	m	67	Parson Russel Terrier	3	Independent-working style
Sixtus	m	77	Petit Barbacon	9	Family-style
Sol	m	18	Shih Tzu	9	Family-style
Sophi	f	128	West Highland White Terrier	3	Independent-working style
Sunny	f	25	Maltese	9	Family-style
Sunny	m	108	Whippet	10	Independent-working style
Toffee	f	42	Bernese Mountain Dog	2	Family-style
Tofu	m	14	Cocker Spaniel	8	Family-style
Yuki	f	60	Siberian Husky	5	Independent-working style
Zira	f	11	Havaneser	9	Family-style
Zoe	f	26	Boston Terrier	9	Family-style

Experimental Set-up

The experiment took place in a 3.33m x 6.05m large testing room of the Clever Dog Lab in the Veterinary University of Vienna (Veterinärplatz 1, 1210 Vienna).

The testing room contained two wooden tunnels, each measuring 1.10 meters in height, 50 centimetres in width, and 60 centimetres in length, that were placed in the middle of the room, 50 centimetres apart from each other. Each of those tunnels was differently coloured: one blue and the other yellow. Inside each of the tunnels two different screens (one opaque, the other transparent) were inserted. The side (left or right) of the transparent screen and whether the yellow or the blue tunnel contained the transparent screen was counterbalanced across dogs. Opaque fences were placed between the tunnels and the walls of the room, which divided the room in two: the dogs' and the experimenters' side. A chair in the dogs' side of the room was positioned for the dog owners to sit on during the experiment. A red cross mark on the floor, that was 240 centimetres apart from the tunnels, indicted the dog's starting position (see Figure 1).

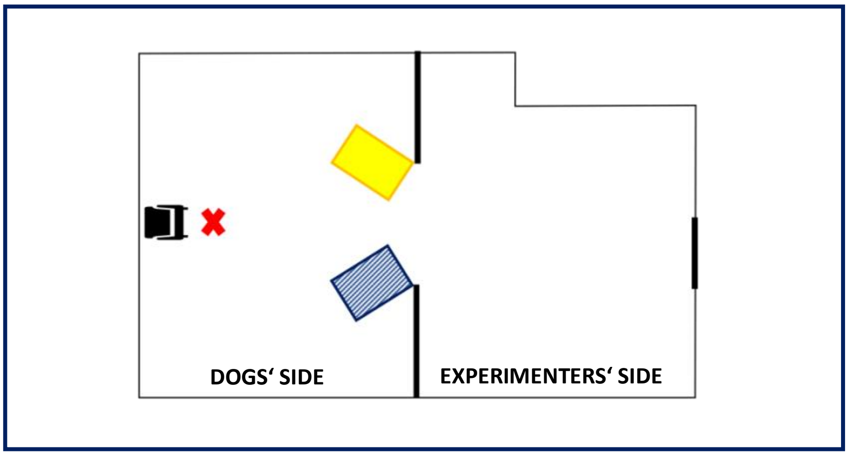

Figure 1: Schematic of experimental set-up: Two wooden tunnels were placed in the middle of a testing room. The tunnels were differently coloured (blue and yellow) and contained two screens each (opaque or transparent). Opaque fences divided the room in two (dogs' and experimenters' side) and a red cross mark on the floor indicated the dog's starting position. A chair behind the red cross mark was placed for the dog-owner. Note that whether the yellow or blue tunnel contained the transparent or opaque screen was counterbalanced across dogs.

Experimental Procedure

The experiment was conducted during a single session with a dog-owner pair with a maximum duration of 60 minutes, including explanations to the owner and breaks for the dog. During testing, the handler was always present and they were asked to wear a blindfold prior to each test trial to avoid inadvertent cueing. They were debriefed about the aim of the experiment and their dog's performance at the end of the session. Water for the dog was always available *ad libitum*.

The experimental procedure consisted of four different phases: the introduction phase, the pre-tests, the experience phase and the test trials.

1. **Introduction phase**

The aim of the introduction phase was to familiarize the subjects to the room and introduce them to the possibility of retrieving food in it.

The unleashed dog and its handler entered and experienced the room as it was described above, but here the tunnels were fully covered by black blankets, so that the tunnels and particularly the screens were not visible to the dog. Additionally, to the standard experimental set-up described above, there were four transparent boxes, which had plates glued on top of them, spread across the room. Food (a piece of sausage) was already placed on those plates when the dog entered the room. The dogs were free to explore and eat the food from the plates on the boxes (see Figure 2).

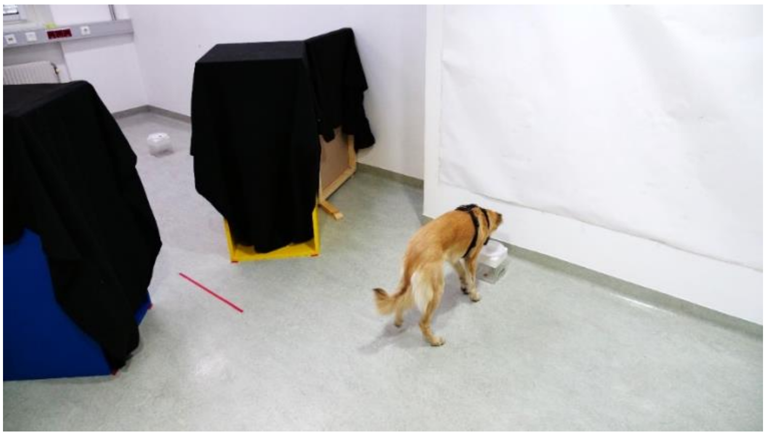

Figure 2: Introduction phase. Dogs were free to explore the room and retrieve food from four plates that were glued on top of transparent boxes, both on the experimenters' and dogs' side of the room. On this picture two out of four boxes are visible. Tunnels were occluded by blankets.

2. Pre-Test

In this phase, the tunnels were still occluded by blankets, but now the experimenter entered the room and stood on her side of the room (experimenters' side) and the dogs and handlers were on the other (dog's side) of the room. The owners were blindfolded and were instructed to sit on the chair and position their dog on the red cross mark on the floor on the collar or harness in front of him/her. This arrange of positions will further be referred to as the "starting position" (see Figure 3).

The first pre-test (pre-test I) has been conducted in order to exclude very disobedient dogs by ensuring that the dogs refrained from taking the food after the experimenter gave them a verbal command combined with the performance of a hand gesture (extended arm with flexed hand) (see Figure 4). This was needed to be understood and followed by the dogs for the final experiment. For that, a verbal command that the dog was already familiar with, was used. By asking the owner beforehand what they usually say when they forbid the dog to eat something, it was ensured that the used commando was known and understood by the dog. In 96.4 % of the cases, the command "bleib" or "stay" was used, while the command "nein" was used with only three dogs from the total sample size including the excluded dogs.

During all times, the experimenter gave the verbal command with moderate intensity and volume while being in a neutral sitting position. The command was given in a determined way without being threatening to the dog. Trials in which the dogs showed any signs of stress or anxiety during or after performing the command in any phase of the experiment, got aborted and the dogs got excluded from the study (see section Subjects).

To evaluate the dogs' boldness, an additional test (Pre-Test II) was conducted to identify dogs that would take the treat when no experimenter was present in the room, despite being instructed not to do so.

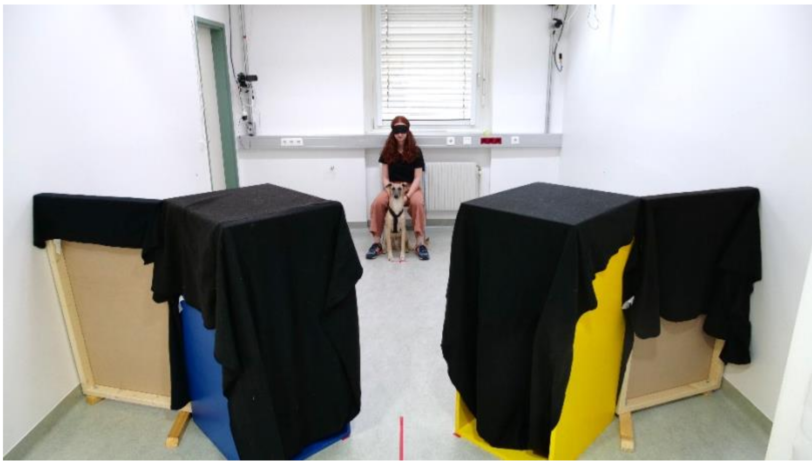

Figure 3: Starting position. The owners were blindfolded and instructed to sit on the chair and position their dog on the red cross mark on the floor holding them on the collar or harness in front of him/her. In the Pre-test phase blankets occluded the tunnels and their screens.

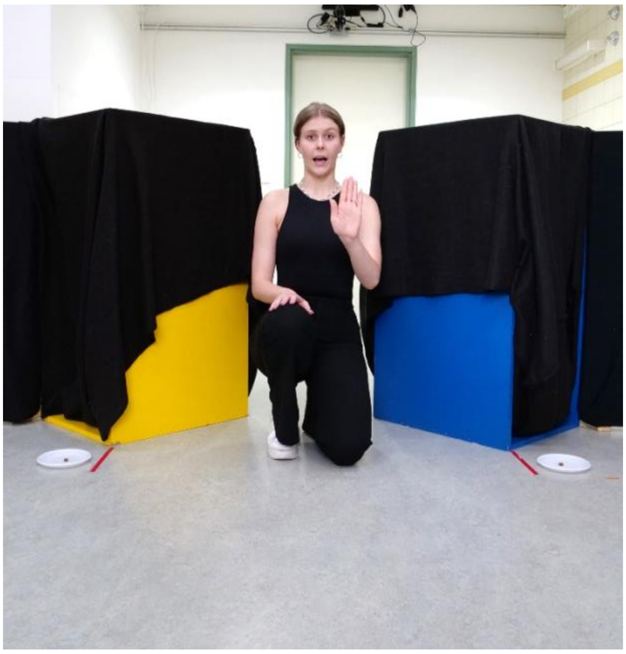

Figure 4: Verbal command ("bleib" or "stay") and visual command (extended arm with flexed hand) given by the experimenter during the Pre-test.

2.1 Pre-Test I (a)

The experimenter, holding two plates and two food items in their hands, started walking towards the dog and their handler from the starting position and stopped between the two tunnels. While crouching down, she placed the two plates in front of each tunnel simultaneously. Next, she took each treat in the left and right hand, showed the treats to the dog and placed the two food items on each of the plates individually, while ensuring that the dog was attentive of the experimenter’s action at all times. After placing the treats on both plates, the experimenter performed the verbal command with the hand gesture described above. Then the experimenter repeated the verbal command, but this time this was the signal for the owner to release the dog, which got explained to the owner before starting the Pre-tests. After the owner released the dog, it had to resist the desire to take the food for 20 seconds.

Did the dogs try to approach the food nonetheless, the experimenter removed the food by picking up the plates in a fast manner and telling the owner to reposition the dog back to the starting position. After that, a new trial started. A maximum of 10 trials were executed. Dogs that did not wait to get the treat for 20 seconds within 10 trials got excluded from the study and the following steps were not performed.

2.2 Pre-Test II

The procedure was the same as in pre-test I but after performing the verbal command and gesture the experimenter left the room. As soon as the door closed behind the experimenter leaving the room, the owner of the dog, who got the instruction before starting the trial, released the dog. In this case, it was anticipated that the dog would attempt to retrieve or begin making their way towards the food within 20 seconds. Dogs that did not steal the treats within eight trials got excluded from the study and the following steps were not performed. To detect potential side-biases in the dogs’ choice, we scored the side of their first choice i.e. whether they stole the treat behind the opaque or transparent tunnel.

2.3 Pre-Test I (b)

Pre-Test I was repeated after Pre-Test II to reinforce once again that the experimenter would intervene and take the food away if she witnessed any stealing attempt. Dogs that did not consistently wait for 20 seconds to receive the treat within these 10 trials were excluded from the study.

3. Experience phase

The aim of this phase was for the dogs to associate the colour of the tunnel with the property of its screen (opaque or transparent). Therefore, during the experience phase and the following steps, the blankets that covered the tunnels were taken down - the tunnels and their screens were now fully visible to the dog. After giving instructions about the procedure to the owner, the dog now was placed on the experimenter's side of the room, where the dog was allowed to move freely, and their owner stood on the opposite side of the room (dog's side). A barrier covered by a black blanket got placed between the tunnels, so the dog only saw the owner's upper body and was not able to go to the dogs' side of the room. The owner got instructed to show firstly a bucket of food and secondly a tennis ball in front of and above each screen. Consequently, the dogs saw the food bucket and tennis ball when it was shown behind the tunnel that contained the transparent screen, and they did not see it when it was shown behind the tunnel containing the opaque screen. In both scenarios, the dogs saw the two items they were shown above the screens (see Figure 5). Whether the yellow or the blue tunnel contained the transparent screen was counterbalanced across dogs

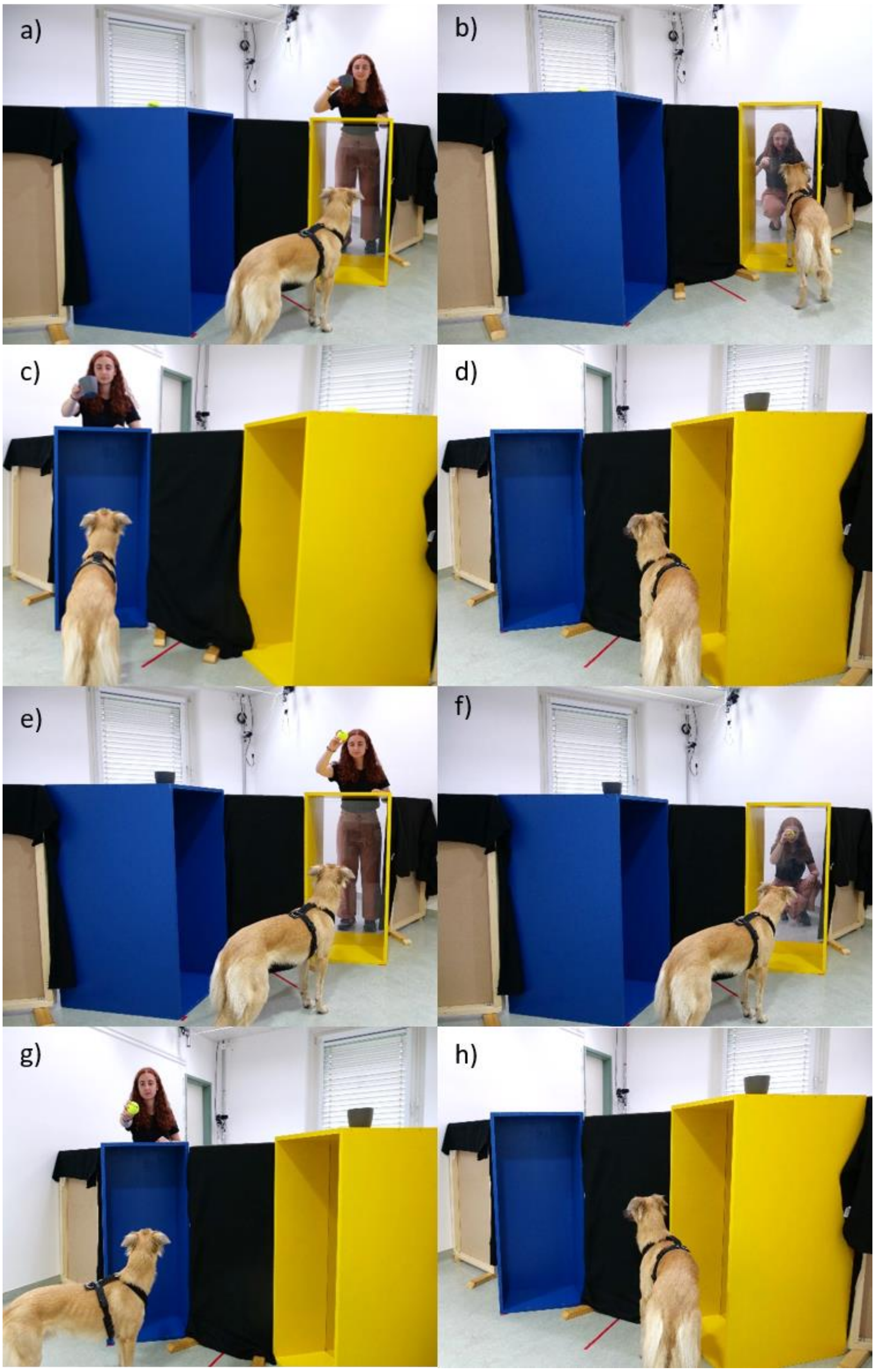

Figure 5: Experience phase. The tunnels and their screens were fully visible to the dog. Dogs were able to move freely on the experimenters' side of the room, the owners were in the dogs' side of the room. A barrier was placed between the tunnels. The experimenter showed a bowl with food above and behind each tunnel (a,b,c,d). After that, the owner showed a tennis ball above and behind each tunnel (e,f,g,h). The owner made sure that the dog was attentive at all times. Whether the yellow or the blue tunnel contained the transparent screen was counterbalanced across dogs.

4. Test phase

Before starting the test phase, the owners were instructed to walk into the room and walk straight to the chair and red cross mark by taking the dog on the leash and/or holding them on the harness very closely to themselves while walking. When the owner and the dog reached the chair and the red cross, they positioned themselves into the starting- position as in the pre-tests. Importantly, the tunnels and their screen were now fully uncovered, but from the dogs' position the dogs only saw the tunnels from an angle, therefore they had not a direct sight of the screens inside of them. A curtain rail with a black curtain was installed between the two tunnels. Before starting the experiment, the curtain was opened.
As in the pre-tests, the experimenter, holding two plates and two food items in their hands, started walking towards the dog and their handler from the starting position and stopped between the two tunnels. While crouching down, she placed the two plates in front of each tunnel simultaneously. Next, she took each treat in the left and right hand, showed the treats to the dog and placed the two food items on each of the plates individually, while ensuring that the dog was attentive of the experimenter's action at all times (see Figure 6). After placing the treats on both plates, the experimenter performed the verbal command with the hand gesture described above (see Figure 7).

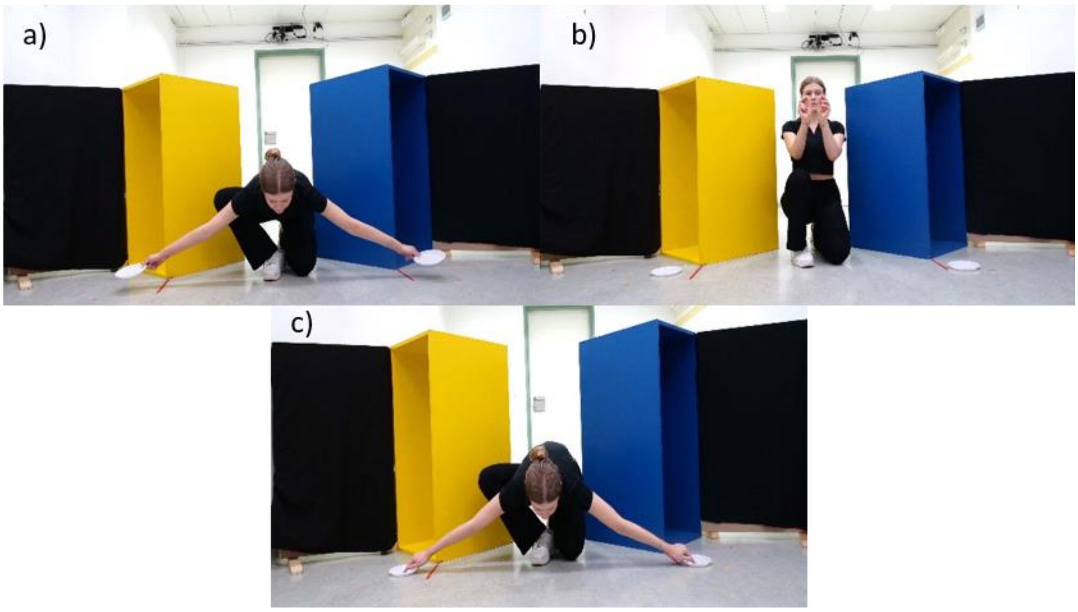

Figure 6: Test phase. The experimenter walked towards the dog and their handler and stopped between the two tunnels. While crouching down, she placed the two plates in front of each tunnel simultaneously (a). Next, she took each treat in the left and right hand, showed the treats to the dogs (b) and placed the two food items on each of the plates individually (c).

Figure 7: Test phase. Handler and dog are on starting position. After placing the treats on both plates, the experimenter performed the verbal command with the hand gesture. The upper picture shows the perspective of the experimenter. Note that the treat in front of the yellow tunnel is visible through the transparent screen. The lower picture shows the perspective of the dog. Note that the dogs did see the tunnels only from an angle, therefore they did not have a direct sight of the screens.

Each dog was presented with four test trials, two for each condition. The conditions were administered in blocks, one block consisting of two trials of the same condition. Whether the dogs experienced the test or control condition first was counterbalanced across subjects. After the first two trials (the first block) the dog and the handler had a short break outside the testing-room. Each trial could get repeated up to 3 times in case the dog did not steal any piece of food on a given test trial.

4.1 Test Condition

After performing the hand gesture and verbal command, the experimenter closed the curtain, so the experimenter was not visible to the dog anymore (see Figure 8). After that, the experimenter repeated the verbal command again, which was the sign for the handler to release the dog. The dog had two minutes to steal at least one piece of food before the trial ended.

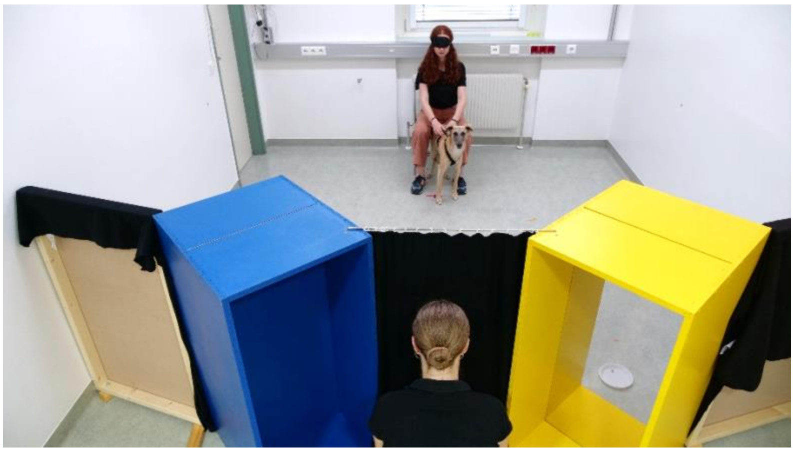

Figure 8: Test phase, Test Condition. After performing the hand gesture and verbal command, the experimenter closed the curtain, so they were not visible to the dog anymore. The experimenter repeated the verbal command again, which was the sign for the handler to release the dog. Note that the treat in front of the yellow tunnel is visible through the transparent screen.

4.2 Control Condition

After placing the treats in front of the tunnels and instructing the dog not to take them, the experimenter closed the curtain and exited the room, ensuring that the dog witnessed their exit. The door closing behind the experimenter was the sign for the handler to release the dog. Again, the dog had two minutes to move/make a choice to which treat to go before the trial ended.

Behavioural Analysis

The entire experiment was videotaped with four different cameras (3x Panasonic HC-V777 & 1x Axis M3045-V). For the behavioural scoring, the video analysis software Loopy (http://loopb.io, Loopbio Gmbh, Vienna, Austria) was used. The dogs' first choice, whether they were more likely to steal first the treat behind the opaque screen (coded as 1) or transparent screen (coded as 0), was scored. The dogs' latencies to make their first choice (first choice latency) from the moment they were released by the owner were scored. Additionally, the latencies to make their second choice (second choice latency) from the moment the dogs made their first choice until they took the second treat were scored.

Statistical Analysis

This study involved conducting both confirmatory and exploratory analyses on the data. The confirmatory analysis was conducted to test the hypothesis that dogs use their experience with the screens inside the tunnels and attribute to the human experimenter. From this hypothesis we derived the prediction that the dogs would be more likely to steal first the treat in front of the opaque screen in the test condition (experimenter present) than in the control condition (experiment absent).

The plan for this statistical analysis was determined before any data was collected (Völter et al., 2022). The exploratory analysis intended to explore any unexpected or intriguing findings that surfaced during the study.

Only trials in which dogs stole at least on piece of food were included in the analysis. An alpha level of 0.05 was used for significance testing. The statistical analysis was conducted in R (R Core Team, 2022). For data-processing and visualization tasks, the package tidyverse was used (Wickham et al., 2019).

The dogs' first choice as well as the potential side-bias using the dogs' choice from Pre-test 2 were analysed using a Generalised Linear Mixed Model (GLMM), fitted with a binomial error distribution using the R package lme4 (Bates et al., 2015). Additionally, intercept-only models were fitted separately for each condition to test against 0.5 in order to assess whether the dogs stole the treat in front of the opaque tunnel significantly more often than expected by chance.

The dogs' latencies to eat the first treat (first choice latency) and the second treat (second choice latency) were analysed using a linear mixed-effects model (lmer). We additionally conducted assumptions checks to ensure the presence of homogenous and normally distributed residuals.

The stability of all models was assessed by removing each level of the random intercept subject ID individually and comparing the resulting estimate. This procedure showed that the models remained stable concerning the fixed effects. Additionally, the relative model complexity was assessed and a value of 26.4 was obtained. The only test predictor included in the models was the condition (test or control). Other control predictors with fixed effects were the order of presentation of conditions (a factor with two levels: test or control first) and/or the trial number within condition (1 or 2), which entered the models as a z-transformed covariate. To account for repeated observations of the same individuals and to allow for individual differences in the strength of the effect, the models included the random intercept of subject ID and the random slope of condition within subject ID. The random slope of condition was centred prior to entering the models. The likelihood ratio test (performed using the R function drop1 with argument test set to 'Chisq') was used to draw inferences about the fixed effects. Collinearity was assessed using variance inflation factors (R package: car; vif function (Fox & Weisberg, 2018)). The maximum variance factor observed was 1.0.

Results

The present experiments aimed to investigate whether pet dogs could utilize their own experience with novel barriers to infer the visual perception of others. The main prediction was that dogs should be more inclined to steal the treat that was placed behind the opaque screen in the test condition (experimenter present) than in the control condition (experimenter absent), after experiencing the properties of the tunnels by themselves.

Confirmatory Analysis

Every tested dog made a first choice in every trial, an exception being two dogs that did not make a first choice in their second trial of the test condition, which leads to a total of 238 first choices, 120 first choices in the control condition and 118 first choices in the test condition that were included into the analysis. Dogs did not choose to steal the treat behind the opaque tunnel in the test condition significantly more often than in the control condition ($\chi2$ (1) = 0.15, p = 0.698), independent of the trial number (1 or 2) within condition and whether they experienced the control (n=30) or test (n=30) condition first (see Table 2 & Figure 9).

In the test condition, the dogs' performance did not deviate significantly from the chance value of 0.5 (z = -0.86, p = 0.391).

Table 2: Results of binomial GLMM of choice performance in all dogs

	Estimate	SE	LowerCI	UpperCI	χ^2	df	p
(Intercept)	-0.24	0.33	-0.91	0.4	-	-	-
conditiontest	-0.12	0.3	-0.74	0.5	0.15	1	0.698
z.trial	-0.09	0.15	-0.4	0.2	0.39	1	0.53
first_conditiontest	0.21	0.43	-0.69	1.15	0.24	1	0.626

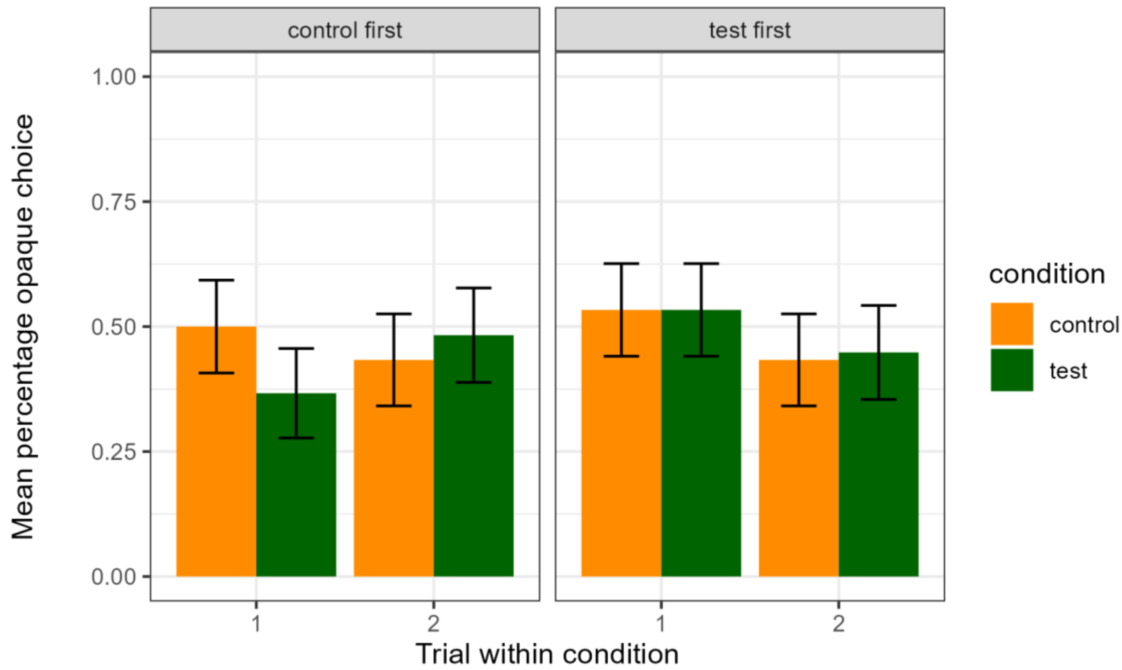

Figure 9: The mean percentage of dogs that chose to steal in front of the opaque tunnel (opaque choice), categorized by the trial number (1 or 2) within the control or test condition (orange or green), with error bars representing the standard error of the mean (SE). The left graph represents dogs that experienced the control condition first (n=30) while the right graph represents dogs that experienced the test condition first (n=30).

After analysing the dogs' first choices from pre-test 2 (opaque or transparent), we fitted another binomial GLMM model to determine if the dogs showed a preference to choose the same side again during the test phase (side bias). Dogs' choice performance in Pre-test 2 was positively correlated with their performance in the testing phase ($\chi2$ (1) = 5.89, p = 0.015) (see Table 3).

Table 3: Results of binomial GLMM of choice performance in Pre-test 2 and in Test phase in all dogs

	Estimate	SE	LowerCI	UpperCI	χ^2	df	p
(Intercept)	0.43	0.42	-0.42	1.31	-	-	-
firstchoice_pretest2transparent	-1.04	0.43	-1.94	-0.19	5.89	1	0.015
conditiontest	-0.11	0.30	-0.75	0.51	0.13	1	0.719
z.trial	-0.09	0.15	-0.38	0.19	0.39	1	0.532
first_conditiontest	-0.01	0.42	-0.84	0.81	0.00	1	0.982

Additionally, to analysing the dogs' first choices in both, the control and test condition, the latencies it took the dogs to make their first choice (first choice latency) as well as the interval between the first and second choice (second choice latency) were analysed. For the test condition, a number of 118 first choice latencies were analyzed, because two dogs did not make a choice in the second trial of the test condition. A total of 114 latencies were analyzed for the second choice, because there were a few cases where dogs did not approach the second treat. Specifically, in 5 trials of the test condition and in one trial of the control condition the dogs did not approach the second treat.

In the test condition, the first choice latency was significantly longer ($t = 7.22$, $p < 0.001$) compared to the control condition. The first choice latencies did not depend on whether the dogs went for the treat behind the opaque or transparent tunnel, which trial the dogs were in and whether their first test condition was the control or test condition (see Table 4). While the dogs in the test condition showed a mean latency of 21.3 (± 3.3) seconds to make their first choice, the dogs in the control condition demonstrated a significantly shorter mean latency of 7.1 seconds (see Figure 10).

Table 4: Results of lmer-analysis of the first choice latencies of all dogs

	Estimate	SE	LowerCI	UpperCI	t_value	p
(Intercept)	1.34	0.17	1.02	1.65	7.95	<0.001
choiceopaque	-0.05	0.13	-0.3	0.2	-0.38	0.702
conditiontest	0.85	0.12	0.63	1.08	7.22	<0.001
z.trial	-0.05	0.05	-0.15	0.05	-0.96	0.34
first_conditiontest	-0.09	0.22	-0.49	0.32	-0.4	0.693

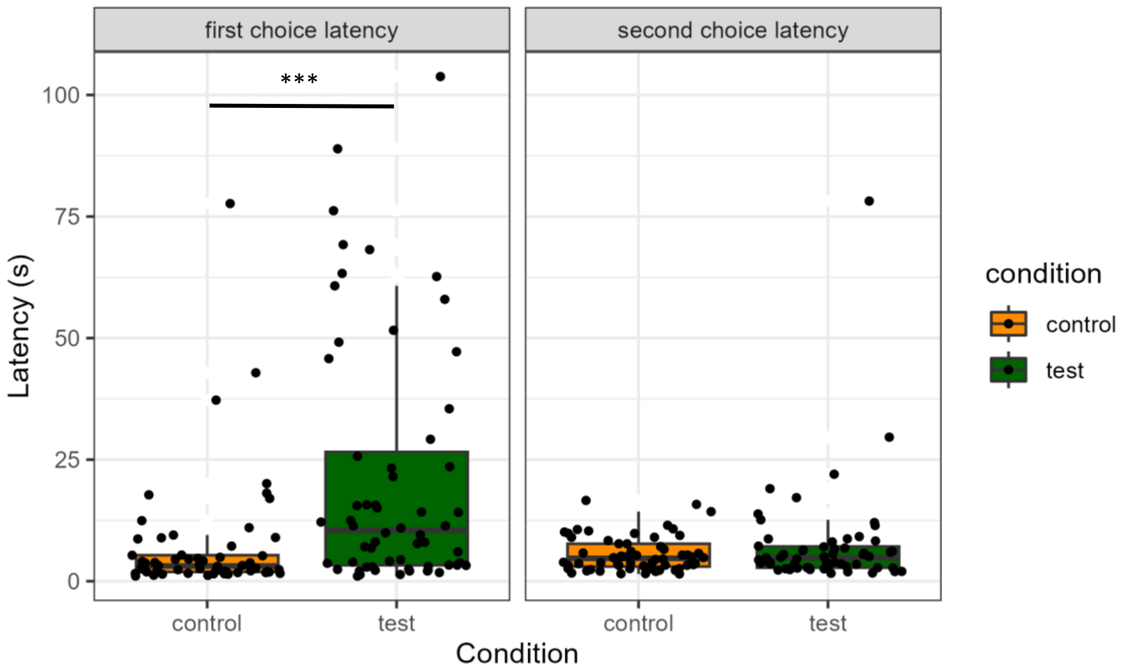

Figure 10: The latency in seconds (s) it took the dogs to decide to steal the first treat (first choice latency, left graph) and the second treat (second choice latency, right graph), depending on whether they were in the test or control condition. The mean latency to steal the first treat was significantly higher (p<0.001) when the dogs experienced the test condition compared to when they experienced the control condition. The plot features box plots with whiskers, representing the distribution of latencies, and dots showing the latencies for each tested dog individually.

For the second choice latency a significant decrease from trial 1 to trial 2 ($t = -3.94$, $p < 0.001$) was found. Dogs approached the second option significantly faster in the control than test condition but only when their first choice was the opaque side ($t = 2.23$, $p = 0.027$) and not when the first choice was the transparent side (see Table 5).

In the test condition, when the dogs' first choice was the opaque side and they subsequently walked to the transparent side, the mean second choice latency was 6.3 (± 1.0) seconds. When the dogs' first choice was the transparent side and they later moved to the opaque side, the mean second choice latency was 7.4 (± 1.3) seconds (see Figure 11).

In the control condition, when the dogs' first choice was the opaque side and they then moved to the transparent side, the mean second choice latency was 5.2 (± 0.6) seconds. When the dogs' first choice was the transparent side and they later moved to the opaque side, the mean second choice latency was 6.0 (± 0.5) seconds (see Figure 11).

Table 5: Results of lmer-analysis of the second choice latencies of all dogs

	Estimate	SE	LowerCI	UpperCI	t_value	p
(Intercept)	1.52	0.11	1.3	1.75	13.4	<0.001
choiceopaque	-0.13	0.09	-0.29	0.05	-1.48	0.141
conditiontest	-0.03	0.09	-0.21	0.16	-0.36	0.718
z.trial	-0.1	0.02	-0.14	-0.05	-3.94	<0.001
first_conditiontest	0.07	0.15	-0.22	0.34	0.46	0.644
choiceopaque:conditiontest	0.28	0.13	0.02	0.53	2.23	0.027

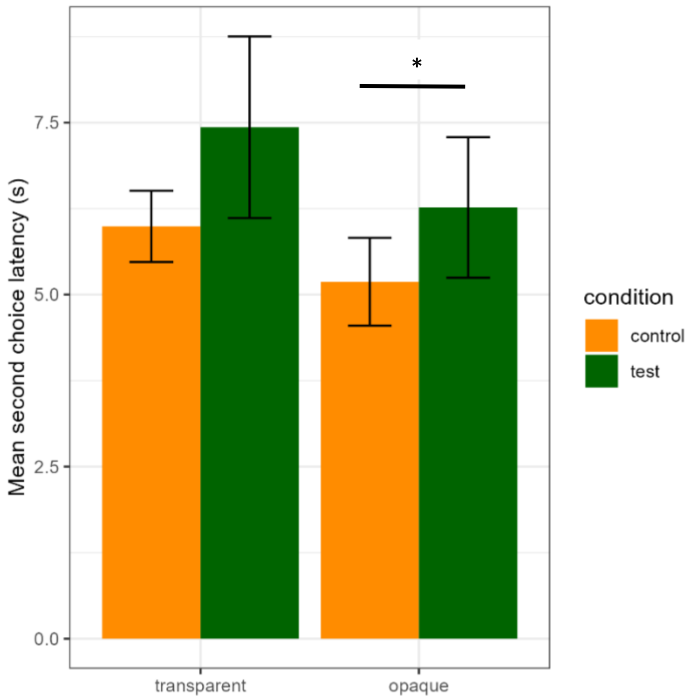

Figure 11: The mean latency in seconds (s) it took the dogs to decide to steal the second treat after they chose either the transparent or opaque tunnel as their first choice site and whether they experienced the test or control condition. When the dogs' first choice site was the opaque tunnel, the mean latency to steal the second treat was significantly higher (p= 0.027) in the test condition than in the control condition. The error bars represent the standard error of the mean (SE).

Exploratory Analysis

The exploratory analysis was conducted to further investigate and gain deeper insights into the data and elaborating on interesting observations made by the experimenter during testing. One focus of interest were the behavioural differences between the tested breed groups.

The tested dogs included breeds that belonged to five different FCI – groups: Sighthounds (FCI-10, n=9), Companion and toy dogs (FCI-9, n=15), Spitz and primitive types (FCI-5, n=4), Terriers (FCI-3, n=21) and Pinscher and Schnauzer (FCI-2, n=8).

Dogs that belonged to the Sighthounds and Pinscher and Schnauzer FCI-Groups descriptively showed a preference for stealing the first treat behind the opaque tunnel more often in the control condition than in the test condition. For the Sighthounds, the mean proportion for choosing to steal behind the opaque tunnel was at 35.3% (± 0.1%) in the test condition and 50% (± 0.1%) in the control condition. For the Pinscher and Schnauzer, 53.3% (± 0.1%) chose to steal behind the opaque tunnel in the test condition and 75% (± 0.1%) in the control condition (see Figure 12).

Companion and Toy dogs as well as Spitz and primitive types showed a preference for stealing the first treat behind the opaque tunnel in the test condition than in the control condition. While Companion and toy dogs chose to steal behind the opaque tunnel in 26.6% (± 0.1%) of the cases, 23.3% (± 0.1%) did that it in the control condition. In the test condition, dogs belonging to the groups of Spitz and primitive types chose to steal behind the opaque tunnel in 50% (± 0.2%) of the cases, while in the control condition, they chose to do so in 25% (± 0.2%) of the cases (see Figure 12).

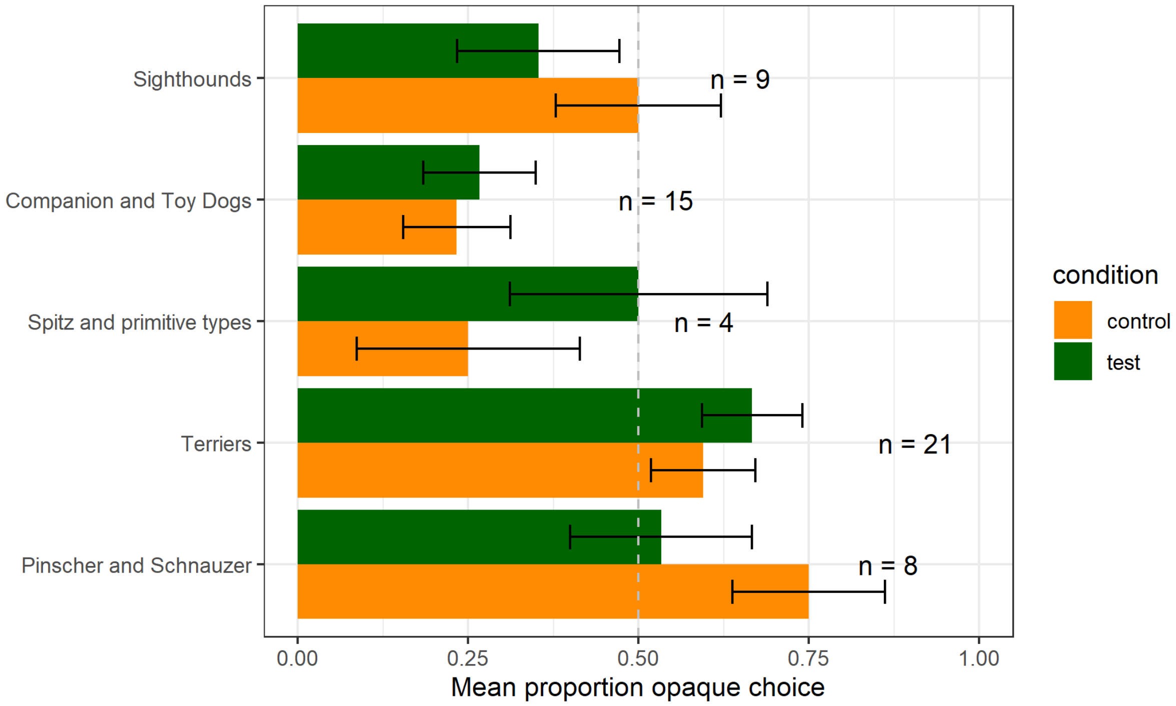

Figure 12: The mean proportion of dogs that chose to steal from the opaque tunnel first in dependence of the different tested FCI- Groups the tested dogs belonged to and the condition they experienced (control or test). The dotted line indicates the chance level at 0.5). The error bars represent the standard error of the mean (SE).

Due to the small sample sizes of the other FCI-groups and the performance of terriers in a previous study in a false-believe task, in which they behaved differently to all other breed groups, the exploratory analysis specifically focused on terriers.

The interaction between the breed group "terrier" and condition was not significant ($\chi2$ (1) = 1.45, p = 0.23). Dogs that belonged to the breed group of terriers chose to steal the treat behind the opaque tunnel significantly more often than behind the transparent tunnel, in both, the test and control condition, than the dogs from all other FCI-groups ($\chi2$ (1) = 9.06, p= 0.003) (see Table 6). While terriers chose to steal the treat behind the opaque tunnel in the test condition with a mean percentage of 66.7% (± 0.1%) of the cases, all other breeds showed a rate of 34.2% (± 0.1%). In the control condition, terriers had a mean percentage of 59.5% (± 0.1%) for choosing to steal behind the opaque tunnel, while the other breeds had a rate of 41.0% (± 0.1%) (see Figure 13). However, no significant differences were found in the terriers' choice between the test and control conditions ($\chi2$ (1) = 0.10, p = 0.747) (see Table 6).

Table 6: Results of binomial GLMM of choice performance in Terriers

	Estimate	SE	LowerCI	UpperCI	χ^2	df	p
(Intercept)	-0.72	0.37	-1.53	-0.06	-	-	-
Terrier (yes/no)	1.31	0.44	0.52	2.33	9.06	1	0.003
conditiontest	-0.10	0.30	-0.73	0.48	0.10	1	0.747
z.trial	-0.10	0.15	-0.41	0.18	0.41	1	0.522
first_conditiontest	0.28	0.40	-0.43	1.05	0.49	1	0.486

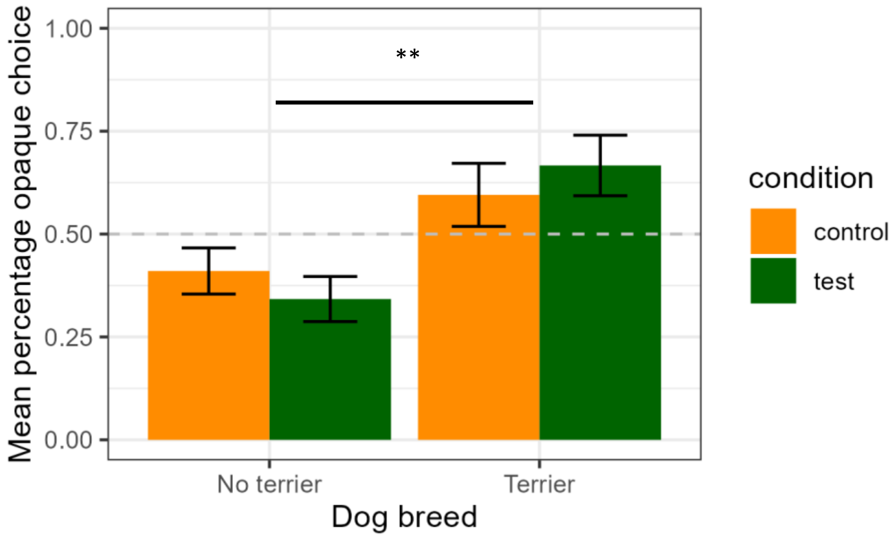

Figure 13: The mean percentage of dogs that chose to steal in front of the opaque tunnel in both the control and test condition in dependence whether the tested dog breeds were part of the FCI-Group 3 (Terriers) or not (No terrier). The dotted line indicates the chance level at 0.5 and the error bars represent the represent the standard error of the mean (SE).

As in the results for all dogs, a condition effect for the mean first choice latencies in the group of terrieres was detected. The terriers took significantly longer ($t = 4.7$, $p > 0.001$) to make their first choice in the test condition (21.0 ± 9.2 seconds) than in the control condition (5.3 ± 1.5 seconds) (see Table 7). Looking at all the other breeds besides Terriers, the results from the analysis stayed cosistent, with “No Terrier”- breeds showing longer first choice latencies in the test condition (23,6 ± 5.6 seconds) than in control condition (9.0 ± 3.5 seconds).

Irrespective of the breed group (terrier or no terrier), we found no significant effect of the chosen tunnel (opaque vs. transparent) on the first choice latency ($t = -0.47$, $p = 0.637$) in either the test or control condition (see Table 7).

The mean latency for the Terriers that did choose to steal the first treat behind the opaque tunnel in the test condition was at 15.4 (± 5.6) seconds, while the dogs that chose the transparent tunnel in the test condition took 26.6 (± 12.7) seconds. For the other breeds besides the Terriers, the mean latency for choosig the opaque tunnel or transparent tunnel in the test condition was 22.0 (± 6.0) and 25.1 (± 5.2) seconds, respectively (see Figure 14). In the control condition, the terriers mean first choice latency was at 5.3 (± 1.5) seconds when they chose both, the opaque or the transparent tunnel as their first choice. The group of all the other breeds besides terriers in the control condition exhibited a mean first choice latency of 9.0 (± 4.0) seconds when they chose the opaque tunnel and 9.1 (± 2.9) seconds when they chose the transprent tunnel as their first choice (see Figure 14).

Table 7: Results of lmer-analysis of the first choice latencies in Terriers (FCI-3)

	Estimate	SE	LowerCI	UpperCI	t_value	p
(Intercept)	1.37	0.29	0.78	1.9	4.7	<0.001
choiceopaque	-0.11	0.23	-0.56	0.34	-0.47	0.637
conditiontest	0.65	0.18	0.3	1	3.59	0.001
z.trial	-0.07	0.08	-0.22	0.09	-0.89	0.375
first_conditiontest	-0.21	0.36	-0.85	0.54	-0.58	0.568

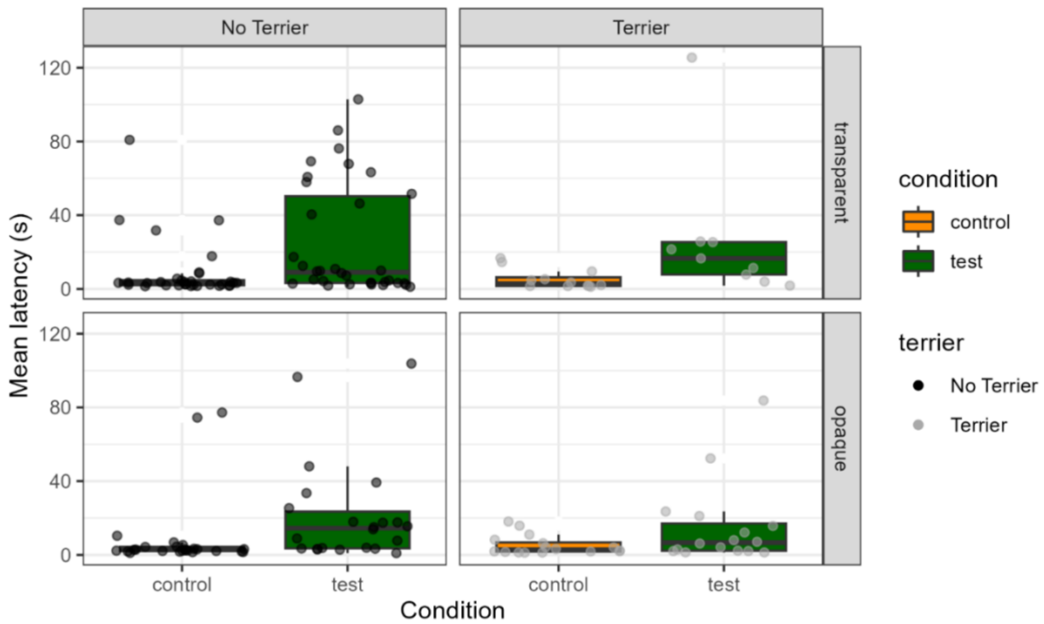

Figure 14: The mean first choice latency in seconds (s) for dogs to steal the first treat, categorized by their condition (test or control), inclusion in the FCI-Group 3 (Terrier or No terrier) and their choice of either the opaque or the transparent tunnel.

Discussion

The aim of the present study was to investigate whether pet dogs can use their own experience with novel barriers to infer if the experimenter can or cannot see through the same barriers. The obtained results show that the dogs' first choices were not significantly modulated by the experimenter's presence (test condition vs. control condition) and that dogs did not choose to steal the treat behind the opaque tunnel more often than behind the transparent tunnel. Looking at the first choice latencies across conditions we found that dogs approached the food more slowly when the experimenter was in the room even though they could not see them. Looking at the main prediction, the findings of the present study do not support the hypothesis that dogs project their own experiences onto others, which might be a critical limitation of their perspective-taking abilities. Importantly, with the current experiment, a new approach was used to test for visual perspective-taking (VPT) in dogs. Unlike other studies, dogs did not have access to any visual cues and could not depend on what they can perceive (altercentric strategy) but had to rely only on their past experiences. The results of this study suggest that dogs cannot solve the task by only inferring the perspective of the experimenter. Instead, we hypothesize that dogs' visual perspective-taking abilities are dependent on what they can perceive (egocentric strategy) when attempting to steal the food, which concurs with the results of other studies (Bräuer et al., 2004; Call et al., 2003; Kaminski et al., 2009).

One can argue that an apparent limitation of the used paradigm is the capability of the subjects to remember the locations of the two different screens. In a study by Bräuer et al. (2004), the authors argue that dogs lack the ability to recall what they had seen. In contrast, the study by Putnik (2022), which used an almost identical approach to familiarize the dogs with the properties of the screens as in this study, obtained clear results. After the experience phase, the dogs were also held centrally between the two tunnels and could no longer see the screens. Once released, they chose, based on their memory of the experience phase, which tunnel to approach to gain a view of the experimenter who was chopping a sausage. Putnik found that the dogs were significantly more likely to approach the tunnel containing the transparent screen first, which provides evidence that the dogs remembered the different properties of the tunnels from the experience phase. Therefore, it is reasonable to assume that the experience phase in the present study was sufficient for the dogs to remember the different properties of the tunnels.

Another source of limitation could be that the dogs' choices throughout the trials in the test phase may have been reinforced by the consistent absence of any consequences to the dog's behaviour; dogs received two treats from each trial without any consequences, regardless of whether they chose the opaque or transparent tunnel to steal from first. Furthermore, the dogs' choice during pre-test 2, in which the tunnels and their screens were still hidden by blankets, significantly influenced their first choice during the testing phase. This carry-over effect indicates a side bias in the dogs' choice, which inevitably influenced the results. Moreover, Heberlein et al. (2017) found that dogs that had not received a training phase to not take the food showed a preference to take it behind a transparent screen, which could be an indicator for the importance of the pre-test phase in the current study. All these limitations could be addressed by repeating pre-test phase 1 in-between the test trials. Accordingly, dogs would be reinforced in their understanding that their stealing attempts result in not getting any food which could potentially make the motivation to make the "right choice" (opaque screen) higher.

Significant differences were found in the dogs' approach latencies towards their first choice site (first choice latency). This indicates that dogs have an understanding of the presence of the experimenter without experiencing visual cues, as the experimenter remained hidden behind the curtain and the dogs therefore were not able to see them. Object permanence research repeatedly demonstrated that dogs can follow visible displacement tasks and therefore understand that objects in their environment still exist even if they leave the dog's immediate perceptual field (Bensky, 2013). The results of the first choice latencies in the present study not only provide additional evidence that dogs do comprehend the presence of, in this case, humans even when they cannot directly perceive them, it also shows that the pre-test phase, in which the dogs learned that they experimenter should not see them stealing the treat, was successful and dogs retained this knowledge until the test phase, at least in the context that it altered the speed of their approach. Call et al. (2003) claimed that dogs may use their slow approach during the test condition to test whether humans would react to them coming closer to the food. It is plausible to hypothesize that dogs were aware that the experimenter could witness their food-stealing actions, but since the experimenter did not react to them coming closer to the treat, their choice from which tunnel to steal was not as relevant. As mentioned earlier, incorporating repeated pre-test 1 trials in-between the test trials in this case could be a promising modification of the procedure in the future. Such repetition could have the potential to possibly show an effect not only in the first choice latencies, but also in their choice from which tunnel to steal the food from.

The study by Bräuer et al. (2013) used a comparable competitive approach as in the present study. Here, the experimenter placed forbidden food in a tunnel that the dogs could retrieve by using their paw. The dogs could not see the experimenter during their food retrieval attempts, but the experimenter could potentially see the dog's paw. In the first experiment the dogs had the choice to take the treat from an opaque or a transparent side of the tunnel, and in the second experiment, they could choose between a silent and a noisy approach. Interestingly, the dogs preferred a silent, but not a hidden approach. The question was why dogs could solve the problem in the auditory but not in the visual modality. Hearing might be more important for dogs than vision, and therefore the information of what others can and cannot hear can be more flexibly used (Bräuer 2013). Another explanation for this might be that while the dog is approaching the tunnel on the crinkly mat, s/he can hear her/himself and therefore knows what the human can (and should not) hear. The usage of this egocentric strategy is a debated topic when discussing perspective-taking abilities in dogs (Huber & Lonardo, 2023). Compared to previous studies (Call et al., 2003; Gácsi et al., 2004; Kaminski et al., 2009; Schwab & Huber, 2006; Virányi et al., 2004) dogs in the present study could not rely on what they can see when attempting to take/steal food. Research shows that dogs steal significantly more when the human's eyes are closed than when they are open or the human is oriented towards the food or oriented away from it (Call et al. 2003; Schwab and Huber 2006). An important aspect is that with the present stealing paradigm dogs could solve the present task only by inferring the perspective of the experimenter (altercentric strategy).

The results regarding the second choice latency support this assumption. We found that dogs who initially chose to steal the first treat behind the opaque screen took significantly longer to approach the second treat located in front of the transparent tunnel. This delay suggests that after witnessing the treat being hidden behind the opaque tunnel, they only then might have gained knowledge about the transparency of the other tunnel. Consequently, they hesitated more to steal the treat from there. It is possible, that with more complex cognitive tasks, in which the application of an altercentric strategy is required to effectively solve the tasks, dogs are unable to fully employ or show limitations in the utilization of this strategy. This effect could be general and unspecific, relating to executive functions like e.g inhibitory control or working memory, or specific to theory of mind tasks. Relying on one's own perspective and experiences might be particularly useful when attributing mental states onto others. To better understand if dogs are capable to use the altercentric strategy in other cognitive processes, including other theory of mind tasks, further research is needed. Although the limitations of the current study need to be considered and could be addressed in future studies, the results that were obtained imply that dogs are not able to infer what someone is seeing when they do not have direct access to visual cues. It is plausible that in pet dogs the VPT-abilities may not be as developed, given that domestication has reduced their need to compete with conspecifics and the application of VPT-abilities may not be as ecologically relevant anymore.

Upon further analysis of the obtained data, a promising finding was that terriers did choose the opaque tunnel significantly more often than other dog breeds, without showing an alteration of their behaviour between the two conditions. A study by Lonardo et al. (2021) revealed that terriers not only behaved differently than other breed groups in a false-believe task, but they showed similar behaviour to human infants and apes tested in previous studies with a similar paradigm. Research on children shows that by the age of 4-5 years they successfully master most Level 2 perspective-taking tasks (Pillow & Flavell, 1986). False-belief reasoning unfolds around the same time (Wellman et al., 2001). Additionally, it was found that false belief and higher-level visual perspective-taking tasks partially activate the same brain areas (Aichhorn et al., 2006). Both, the results of this study and the one of Lonardo et al. (2021), which show differences in the behaviour of terriers to other breed groups, align with the relationship between false-belief reasoning and perspective-taking abilities. Regarding the categorization of working style by Heberlein et al. (2017), terriers belong to the independent-working style group. As the name suggests, dogs with an independent working style have been bred to work without any human visual contact, while cooperative breeds have been selected for cooperating while keeping continuous visual contact with their human partner (Lonardo et al., 2021). The categorization of dog breeds into family or independent working groups, as described by Heberlein et al. (2017), lacks clarity regarding the specific factors involved. One could argue that breeds that fall into the category of independently- and family-style-working breeds show varying degrees of independence in their working style. In other words, within the independently and family-style working breeds, certain breeds might exhibit a higher level of independent work than others. Additionally, it is important to consider the sample sizes in the study. A total of 21 terriers were a part of this study, while the number of dogs from other breeds belonging to the independent working style group, which also showed a tendency for choosing to steal behind the opaque screen as the spitz and primitive types (n=4), was lower. These differences in the sample sizes might explain why significant results were found in terriers but not in other breeds within the same working group. It is also possible that terriers are simply more cognitively skilled than other breeds. Terriers originally have been bread to hunt for vermin (King, 2011), where the usage of VPT-abilities could have led to better performances and therefore to the selective breeding of dogs that mastered the task well. Heberlein's study aimed to demonstrate dogs' attentiveness to others' (their owners) perceptions, while the current study required dogs to not only pay attention to others' (the experimenters') perspectives but also do this without direct visual access to the screens. In addition, dogs in the present study had to infer what others could see based on their memory of past experiences. Given the significant results observed in this study with a sample of only 21 terriers, future studies could explore VPT abilities in terriers more extensively. It would be intriguing to discover whether testing a larger number of terriers using the same paradigm would lead to differences between conditions and find explanations for why terriers seem to be more cognitively skilled than other breeds, at least in false-believe and perspective-taking tasks. The findings in the cognitive abilities in terriers raise intriguing questions that require further investigation. Furthermore, particular interest could be examining whether there is a correlation between the two cognitive abilities across other breeds than terriers.

The current study did not replicate the findings that all dogs from the independent- and family style - working groups prefer to steal food that is not visible to another person. It is important to mention that in the current study, differently from various other recent studies that studied and found positive evidence for VPT-abilities in dogs, the dog-experimenter relationship, rather than the dog-owner relationship, was utilized. Schwab & Huber (2006) underline the advantages that occur with using dog-owner relationships when studying the cognitive performance of dogs. Topál et al. (1997) showed that dogs show their best cognitive performance in a highly familiar situation and with their most familiar human partner. The results of a more recent study by Kiss and Topál (2019) confirm that dogs preferably relied on cues given by their owner when deciding to whether obey or disobey to steal forbidden food. Due to feasibility constraints, the present study could not include the owners of the dogs in the role of the experimenter, but future VPT-studies in dogs could try to include this possibly important factor.

In sum, the results of this study do not support perspective-taking in dogs by projecting self-experience onto others without direct cues (e.g. access to humans' line of sight). Dogs' visual perspective-taking abilities might be dependent on what they can perceive (egocentric strategy) when attempting to steal food. However, neither do the current findings support a low-level account, for example, that dogs are using a single discriminatory cue (such as presence or absence of eyes) to guide their behaviour with humans. Knowledge about the presence of the experimenter behind the curtain at least changed the approaching behaviour of dogs in the way that the dogs approached the forbidden food slower when the experimenter was hidden behind the curtain than when they left the room. The used paradigm in this study is intriguing and holds, with some changes, like the repetition of pre-test 1 in between the test trials or making use of the human-owner relationship, promise for future research. We found evidence that terriers behaved significantly different to other breeds which is in line with work by Lonardo et al. (2021). Future work should explore the possibly unique cognitive abilities that seem to be present in terriers. Future work could also focus on developing novel test paradigms that determine which levels of perspective taking dogs possess more conclusively. So far, dogs' performance seems inconsistent and further studies are needed to clarify this issue.

References

Aichhorn, M., Perner, J., Kronbichler, M., Staffen, W., & Ladurner, G. (2006). Do visual perspective tasks need theory of mind? *NeuroImage*, *30*(3), 1059–1068. https://doi.org/10.1016/j.neuroimage.2005.10.026

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using **lme4**. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Bensky, M. K. (2013). *A review and synthesis of dog cognition research: The world from a dog's point of view*. https://repositories.lib.utexas.edu/handle/2152/22383

Bräuer, J. (2014). What Dogs Understand about Humans. In *The Social Dog* (pp. 295–317). Elsevier. https://doi.org/10.1016/B978-0-12-407818-5.00010-3

Bräuer, J., Call, J., & Tomasello, M. (2004). Visual perspective taking in dogs (Canis familiaris) in the presence of barriers. *Applied Animal Behaviour Science*, *88*(3), 299–317. https://doi.org/10.1016/j.applanim.2004.03.004

Bräuer, J., Keckeisen, M., Pitsch, A., Kaminski, J., Call, J., & Tomasello, M. (2013). Domestic dogs conceal auditory but not visual information from others. *Animal Cognition*, *16*(3), 351–359. https://doi.org/10.1007/s10071-012-0576-9

Bugnyar, T., & Heinrich, B. (2005). Ravens, Corvus corax, differentiate between knowledgeable and ignorant competitors. *Proceedings of the Royal Society B: Biological Sciences*, *272*(1573), 1641–1646. https://doi.org/10.1098/rspb.2005.3144

Call, J., Bräuer, J., Kaminski, J., & Tomasello, M. (2003). Domestic dogs (Canis familiaris) are sensitive to the attentional state of humans. *Journal of Comparative Psychology*, *117*(3), 257–263. https://doi.org/10.1037/0735-7036.117.3.257

Catala, A., Mang, B., Wallis, L., & Huber, L. (2017). Dogs demonstrate perspective taking based on geometrical gaze following in a Guesser–Knower task. *Animal Cognition*, *20*(4), 581–589. https://doi.org/10.1007/s10071-017-1082-x

Flavell, J. H., Green, F. L., Flavell, E. R., Watson, M. W., & Campione, J. C. (1986). Development of Knowledge about the Appearance-Reality Distinction. *Monographs of the Society for Research in Child Development*, *51*(1), i–87. https://doi.org/10.2307/1165866

Fox, J., & Weisberg, S. (2018). *An R Companion to Applied Regression*. SAGE Publications.

Gácsi, M., Miklósi, Á., Varga, O., Topál, J., & Csányi, V. (2004). Are readers of our face readers of our minds? Dogs (Canis familiaris) show situation-dependent recognition of human's attention. *Animal Cognition*, *7*(3), 144–153. https://doi.org/10.1007/s10071-003-0205-8

Heberlein, M. T. E., Turner, D. C., & Manser, M. B. (2017). Dogs' (Canis familiaris) attention to human perception: Influence of breed groups and life experiences. *Journal of Comparative Psychology*, *131*(1), 19–29. https://doi.org/10.1037/com0000050

Heyes, C. M. (1998). Theory of mind in nonhuman primates. *Behavioral and Brain Sciences*, *21*(1), 101–114. https://doi.org/10.1017/S0140525X98000703

Huber, L., & Lonardo, L. (2023). Canine perspective-taking. *Animal Cognition*, *26*(1), 275–298. https://doi.org/10.1007/s10071-022-01736-z

Kaminski, J., Bräuer, J., Call, J., & Tomasello, M. (2009). Domestic Dogs Are Sensitive to a Human's Perspective. *Behaviour*, *146*(7), 979–998.

Kaminski, J., Call, J., & Tomasello, M. (2006). Goats' behaviour in a competitive food paradigm: Evidence for perspective taking? *Behaviour*, *143*(11), 1341–1356. https://doi.org/10.1163/156853906778987542

Kaminski, J., Pitsch, A., & Tomasello, M. (2013). Dogs steal in the dark. *Animal Cognition*, *16*(3), 385–394. https://doi.org/10.1007/s10071-012-0579-6

Kano, F., Krupenye, C., Hirata, S., Tomonaga, M., & Call, J. (2019). Great apes use self-experience to anticipate an agent's action in a false-belief test. *Proceedings of the National Academy of Sciences*, *116*(42), 20904–20909. https://doi.org/10.1073/pnas.1910095116

Karg, K., Schmelz, M., Call, J., & Tomasello, M. (2016). Differing views: Can chimpanzees do Level 2 perspective-taking? *Animal Cognition*, *19*(3), 555–564. https://doi.org/10.1007/s10071-016-0956-7

King, H. H. (2011). *Working Terriers, Badgers and Badger Digging (History of Hunting Series)*. Read Books Ltd.

Kiss, O., & Topál, J. (2019). How do dogs monitor the human's attentional state after challenged by the presence of forbidden food? *Biologia Futura*, *70*(2), 103–111. https://doi.org/10.1556/019.70.2019.13

Krupenye, C., & Call, J. (2019). Theory of mind in animals: Current and future directions. *WIREs Cognitive Science*, *10*(6), e1503. https://doi.org/10.1002/wcs.1503

Lonardo, L., Völter, C. J., Lamm, C., & Huber, L. (2021). Dogs follow human misleading suggestions more often when the informant has a false belief. *Proceedings of the Royal Society B: Biological Sciences*, *288*(1955), 20210906. https://doi.org/10.1098/rspb.2021.0906

Maginnity, M., & Grace, R. (2014). Visual perspective taking by dogs (Canis familiaris) in a Guesser-Knower task: Evidence for a canine theory of mind? *Animal Cognition*, *17*. https://doi.org/10.1007/s10071-014-0773-9

Perner, J., & Roessler, J. (2012). From infants' to children's appreciation of belief. *Trends in Cognitive Sciences*, *16*(10–10), 519–525. https://doi.org/10.1016/j.tics.2012.08.004

Pillow, B. H., & Flavell, J. H. (1986). Young Children's Knowledge about Visual Perception: Projective Size and Shape. *Child Development*, *57*(1), 125–135. https://doi.org/10.2307/1130644

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*(4), 515–526. https://doi.org/10.1017/S0140525X00076512

Putnik, M. (2022). *Dogs' ability to project their own experience onto others*. Linköping University.

R Core Team. (2022). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. https://www.R-project.org/.

Sandel, A. A., MacLean, E. L., & Hare, B. (2011). Evidence from four lemur species that ringtailed lemur social cognition converges with that of haplorhine primates. *Animal Behaviour*, *81*(5), 925–931. https://doi.org/10.1016/j.anbehav.2011.01.020

Schwab, C., & Huber, L. (2006). Obey or Not Obey? Dogs (Canis familiaris) Behave Differently in Response to Attentional States of Their Owners. *Journal of Comparative*

Psychology (Washington, D.C. : 1983), *120*, 169–175. https://doi.org/10.1037/0735-7036.120.3.169

Topál, J., Miklósi, Á., & Csányi, V. (1997). Dog-Human Relationship Affects Problem Solving Behavior in the Dog. *Anthrozoös*, *10*(4), 214–224. https://doi.org/10.2752/089279397787000987

Virányi, Z., Topál, J., Gácsi, M., Miklósi, Á., & Csányi, V. (2004). Dogs respond appropriately to cues of humans' attentional focus. *Behavioural Processes*, *66*(2), 161–172. https://doi.org/10.1016/j.beproc.2004.01.012

Völter, C., Szewczak, V., Lonardo, L. & Huber, L. (2022). *Stealing behind tunnels: Do dogs use self-experience in a perspective-taking task?* osf.io/4m9pf

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief. *Child Development*, *72*(3), 655–684. https://doi.org/10.1111/1467-8624.00304

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T., Miller, E., Bache, S., Müller, K., Ooms, J., Robinson, D., Seidel, D., Spinu, V., … Yutani, H. (2019). Welcome to the Tidyverse. *Journal of Open Source Software*, *4*(43), 1686. https://doi.org/10.21105/joss.01686

Xitco, M. J., Gory, J. D., & Kuczaj, S. A. (2004). Dolphin pointing is linked to the attentional behavior of a receiver. *Animal Cognition*, *7*(4), 231–238. https://doi.org/10.1007/s10071-004-0217-z