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ORIGINAL PAPER

Looking back at 'looking back': operationalising referential gaze for dingoes in an unsolvable task

Bradley Philip Smith · Carla Anita Litchfield

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Abstract This paper examined the performance of dingoes (*Canis dingo*) on the rope-pulling task, previously used by Miklósi et al. (Curr Biol 13:763–766, 2003) to highlight a key distinction in the problem-solving behaviour of wolves compared to dogs when in the company of humans. That is, when dogs were confronted with an unsolvable task, following a solvable version of the task they looked back or gazed at the human, whereas, wolves did not. We replicated the rope-pulling task using 12 sanctuary-housed dingoes and used the Miklósi et al. (Curr Biol 13:763–766, 2003) definition of *looking back* behaviour to analyse the data. However, at least three different types of *look backs* were observed in our study. We, then developed a more accurate operational definition of *looking back* behaviour that was task specific and reanalysed the data. We found that the operational definition employed greatly influences the results, with *vague* definitions potentially overestimating the prevalence of *looking back* behaviour. Thus, caution must be taken when interpreting the results of studies utilising *looking back* as behaviour linked to assistance seeking during problem solving. We present a more stringent definition and make suggestions for future research.

B. P. Smith (✉)
Appleton Institute, Central Queensland University, 44 Greenhill Road, Wayville, South Australia 5034, Australia
e-mail: howlingdingo@gmail.com; b.p.smith@cqu.edu.au

B. P. Smith
Australian Dingo Foundation, Toolern Vale,
Victoria 3337, Australia

C. A. Litchfield
School of Psychology, Social Work and Social Policy,
University of South Australia, Magill,
South Australia 5072, Australia

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Introduction

Domestic dogs (*Canis familiaris*) and wolves (*Canis lupus*) adopt distinctly different problem-solving strategies during times of conflict and uncertainty. These differences are most evident when dogs and wolves are confronted with a difficult or unsolvable problem in the presence of a human. In general, wolves prefer to work independently, attempt several strategies, and show persistence, whereas, domestic dogs often give up easily and gaze or *look back* towards a nearby human for assistance. For example, after presenting wolves and dogs with a *puzzle box* task, Frank and Frank (1985) noted that wolves generally *attacked* the problem until they had solved it or the trial ended. In contrast, dogs investigated the puzzle box, and after discovering the food was not easily accessible, "performed a variety of solicitation and begging gestures" towards the nearby experimenter (p. 271).

In a seminal paper, Miklósi et al. (2003) gave four-month-old hand-reared wolf and dog pups the opportunity to learn (by trial-and-error) how to obtain a food reward by either pulling on a rope or opening a bin lid. Once the subjects had mastered the task, a blocked trial was presented, and the task became unsolvable (i.e. the rope could not be moved, or the bin could not be opened). During training, both wolves and dogs performed equally well. However, once the task was unsolvable, dogs looked or gazed towards their owner/caregiver who was standing behind them. The socialised wolves appeared to ignore their owner/caregiver and instead, persistently attempt to solve the problem independently. Marshall-Pescini et al.

(2009) support these findings, reporting that 85 % of dogs tested looked back during the unsolvable version of the task (a container containing food was able to be overturned in the learning trials, but the container was fixed onto a wooden board during the blocked trial).

The likelihood that dogs will *look back* or gaze towards a human is not limited to situations where previously successful strategies no longer become effective. Dogs have been reported to *look back* at people during other problem-solving tasks, including the detour task (Pongrácz et al. 2005), object choice paradigm (Virányi et al. 2008), in situations where dogs witness an object of desire being hidden (Gaunet and Deputte 2011; Miklósi et al. 2000), placed out of reach (Barrera et al. 2011; Jakovcecvic et al. 2010), or when dogs are confronted with a potentially scary object (e.g. an electric fan with plastic green ribbons attached to it, Merola et al. 2012).

Wolves, by contrast, exhibit a tendency to avoid making eye contact with humans and generally display less communicative signals that could potentially facilitate social interaction with humans (Gacsi et al. 2005). In general, wolves perform poorly compared to dogs in human-guided tasks (e.g. Virányi et al. 2008), but along with socialised coyotes and dingoes, wolves have been found to be sensitive to a range of human-directed signals under some conditions (see Udell et al. 2008, 2011, 2012; Smith and Litchfield 2010). In fact, Range and Viranyi (2011) investigated the gaze following of wolves and found that they are capable of following both human and conspecific gaze from behind a barrier, as well humans gazing into distant space, which dogs appear unable to do (Agnetta et al. 2000).

Not only do dogs show a tendency to make eye contact with their owner during problem-solving tasks (Gaunet 2008, 2009; Miklósi et al. 2005), but they also alternate their gaze between the person and the object of desire (Gaunet and Deputte 2011; Merola et al. 2012; Miklósi et al. 2000). For example, Miklósi et al. (2000) found that dogs who saw where food or a toy was hidden whilst the owner was out of the room vocalised and alternated their gaze between the person and the hidden object when they returned, so that the owner was able to locate the object in the hidden location. Taken together, these studies indicate that dogs communicate with humans for assistance by making direct eye contact with them, alternate their gaze between the problem and human, or more generally show signs of frustration (Gaunet and Deputte 2011). That is, dogs perceive humans as a tool to achieve a goal (Cooper et al. 2003; Hare 2004). A dog's gaze or *looking* behaviour in these situations is reinforced because the human responds by helping solve the problem.

The ability or tendency of dogs to gaze at the human face may be the result of the phylogenetic domestication process, being independent of individual histories or learning (Gacsi et al. 2005; Miklósi et al. 2003; Miklósi 2007). Yet, gazing or looking behaviour of dogs appears heavily dependent on environmental and life experiences, such as prior learning and training during ontogeny (Barrera et al. 2011; Passalequa et al. 2011). For example, gazing behaviour is highly responsive to associative learning (Barrera et al. 2011; Bentosela et al. 2008, 2009) and differs according to individual training experience (Bentosela et al. 2008; Marshall-Pescini et al. 2009). The level of human interaction during development also influences gazing behaviour in domestic dogs, with dogs living in shelters showing significant shorter gaze duration than pet dogs (Barrera et al. 2011). Barrera et al. (2011) suggest that pet dogs have more opportunities to learn to persist in their communicative responses when they do not get what they want. Finally, differences exist in relation to breed (Jakovcevic et al. 2010; Passalacqua et al. 2011), as well as the sociability of the dog, with more sociable dogs being more willing to look (Jakovcevic et al. 2012).

Whilst it appears that there is a clear distinction between dogs and wolves in their communication with humans, this paper argues that the operational definitions and terms used for *looking back* behaviour of canids during human–dog interactions are too numerous and lack specific details about the topography of the response. For example, the operational definition of "visual contact" of a dog with a human (e.g. owner, stranger, or experimenter) during a task or situation may provide little description beyond the category label itself (e.g. Barrera et al. 2011, p.730; Bentolosa et al. 2008, 2009, p.127; Jakovcevic et al. 2012, p. 604) or describes the orientation of the dog's head or nose towards the human without specifying which area of the human body the dog's gaze is directed towards to be regarded as a referential gesture (Miklósi et al. 2003, p. 766). A few researchers have specified that orientation must be directed towards the human head (Gaunet 2008, p. 479; Gaunet and Deputte 2011) or face (Jakovcevic et al. 2012). The position of the dog's body and behaviour during gazing is seldom described, but is assumed to occur when the dog is stationary and "turns/lifts its head towards the person" (Marshall-Pescini et al. 2009, p. 419). Another common omission from the operational definition is the length of time of unbroken visual contact or gaze before it is considered referential (with the exception of Bentosela et al. 2009, who stated that the look must occur for one second). For research with human infants, unbroken reciprocal eye contact between an infant and another person is needed to confirm that both are *on line* and ready to receive/give a message (Csibra 2010).

A standardised set of operational definitions is required, incorporating clear distinctions between referential and non-referential gazes. To date, it remains unclear which definitions of gazing or attention-seeking behaviours are truly referential in nature. Perhaps, the most accurate operational definition so far is that of *gaze alternation*. Merola et al. (2012) define *referential gazing* as a two-step sequence (e.g. a look at the object and then a look towards the person) and *gaze alternation* as a three-step sequence whereby, the animal alternates its gaze directly between a target and the human (or vice versa), within a short period of time, typically 2 s (e.g. Gaunet and Deputte 2011; Marshall-Pescini et al. 2009). However, a further complication may arise when researchers do not specify or acknowledge whether gaze-alternation sequences are important, such as *target–human* (or vice versa) or *target–human–target* (or vice versa). Animals may look back and forth in different sequences, or number of gaze alternations.

The current study began as a simple attempt to extend the literature on gazing behaviour in canids by determining whether dingoes (*Canis dingo*), a wild canid endemic to Australia, would show a tendency to look back to humans during an unsolvable task. In Study 1a, we sought to replicate the original rope-pulling experiment conducted by Miklósi et al. (2003). However, following replication of this study, it became apparent that the operational definitions of *looking back* provided by Miklósi et al. (2003) did not adequately describe the topography of behaviours observed in our study. As we were unsure how this would impact on the findings, in Study 1b, we reanalysed the data set using a more thorough description of *looking* behaviour that appears to be context dependent when wild canids are restrained during experimental tasks.

Methodology

Participants

Twelve *pure* dingo puppies from six different litters were used in this study, ranging in age from 14 to 26 weeks (M = 21 weeks, SD = 5.17). Purity was confirmed by inspecting paperwork of the parents' detailing results from an established and independent DNA test previously conducted by the University of New South Wales using cheek swab samples (Wilton 2001), in conjunction with an assessment of phenotypic characteristics (morphology and coat colour), and the existence of an annual breeding cycle. All dingoes were captive born and reared at the Dingo Discovery Centre, Victoria, Australia (with the exception of Wirra and Solo who were born and reared at Wild Action Zoo, Victoria, Australia, a private (educational) zoo until the age of 8 weeks when they were permanently relocated to the Dingo Discovery Centre. These dingoes had received similar socialisation and appeared well adjusted). For those dingoes raised at the sanctuary, socialisation began at 1–3 days of age, with pups handled gently for brief periods by human volunteers in the presence of their mother(s). At 4–5 weeks of age, different litters of pups spent their days together in puppy pens (5 m × 2.5 m or 12.5 m^2). From 5 weeks of age, pups were no longer housed with their mothers at night and interacted with human (familiar volunteer staff and visiting public of various ages) and other conspecifics (pups and adults) during the daytime in large exercise yards. Toys were available daily, with other enrichment items (including bones and carcasses) provided on an ad hoc basis. Puppies and juvenile dingoes (less than 12 months of age) were fed twice per day a combination of dry food and fresh chicken (carcass or ground carcass mince). Most dingoes received basic obedience training as pups, such as to sit on command and to walk on a leash (however, the use of a leash or restraint at the sanctuary was rare). For further details of rearing procedures, see Smith (2010).

Dingo puppies (under 6 months of age) at the sanctuary were selected as suitable for testing if they could be comfortably handled and placed on a leash and showed no obvious fear response to being on a leash, the experimenter, equipment or the testing scenario. These criteria were not met for the sub-adult and adult dingoes at the sanctuary. Table 1 provides a descriptive summary of the 12 subjects tested.

Apparatus and procedure

Experiments were conducted in the sanctuary's puppy enclosure (15.35 m^2 in area). To solve this task, each dingo had to learn (by trial-and-error) to pull a piece of rope towards itself in order to reach a piece of meat attached to the end of the rope housed within a metal dog crate (see Fig. 1). The first dingo tested on the blocked trail

Table 1 Dingoes according to age, sex, and litter identification

Dingo	Age (weeks)	Sex	Litter ID
Wirra	14	F	1
Solo	14	F	1
Tele	16	F	2
Tubby	16	F	2
Tinky	16	M	2
Uno	25	F	3
Max	25	M	3
Nutmeg	25	F	3
Petal	25	F	4
Rosie	25	F	4
Fanta	25	F	5
Snapple	26	M	6

Fig. 1 A side view of the experimental setup. The piece of board closest to the front of the cage (12 cm × 58 cm) was attached to the base of the cage. A second piece of wood (30 cm × 59 cm) rested behind it. A 50 cm piece of rope (with a knot at one end) was positioned so that 20 cm protruded from the cage. During *blocked* trials (pictured), the rope was attached to the wire base of the cage with a second piece of rope and then hidden by the second board (see Fig. 2)

(unsolvable version of task) pulled the rope so forcefully that the cage moved on the concrete surface. As a result, the cage was weighted down for subsequent trials.

The dingo was positioned 1.5 m in front of a wire mesh cage (commercially available dog crate; 90 cm × 60 cm × 66 cm) and held on a leash by a familiar caretaker (Experimenter 1, E1) who was located 1 m behind the dingo (starting position). E1 was a full-time volunteer at the sanctuary and had daily contact with each dingo pup that included feeding, grooming, training, and playful interactions. In order to familiarise the dingoes with the task, one and two warm-up trials were given. During the warm-up trials, experimenter 2 (E2) crouched into the cage and offered the dingo the tip of a chicken wing (the reward used for all tests) through the mesh. E2 then attached the meat to the rope and offered the rope and meat to the subject through the cage in order for the dingo to associate the rope with the meat. Following this, a piece of meat was attached to the end of the rope furthest away from the dingo, and the dingo was given an opportunity to pull at the rope and retrieve the meat. In the rare event that a dingo did not manage to retrieve the meat, a demonstration from E1 was provided (i.e. how to pull the rope out of the cage). Two dingoes (aged 13 weeks; not included in Table 1) were excluded from the experiment at this stage. One of these pups remained fearful of the testing scenario, whilst the other was unable to grasp the task even after six trials.

Once the dingo had successfully pulled the rope and retrieved the meat by itself (10 dingoes required one attempt, 2 required two attempts), E1 led the dingo out of view (behind a dog kennel). E2 then placed a piece of meat 5 cm from the end of a 50 cm nylon rope (8-mm thick) at the end furthest away from the dingo. By slightly loosening the rope threads (by twisting the rope), the meat was held in place when the threads twisted back into place. At the other end of the rope, closest to the dingo, a large knot was created to allow the dingo to grip the rope. It was not known whether dingoes would use their mouth or paw to pull the rope so a knot was made to provide some grip. The knot was available for both training and blocked trials. The knotted end remained outside the cage, whilst the rest of the rope was laid flat along two wooden boards inside the cage. Once flat, the meat reward was 30 cm inside the cage, and the knot was 20 cm outside the cage (see Fig. 1). E1 led the dingo to the starting position, and as soon as it oriented towards the cage, it was released (but still held loosely by the leash by E1) and allowed to eat the reward once it was retrieved. This process was repeated five times in succession.

On the sixth occasion, the trial was blocked by threading a separate piece of rope through the original rope threads and tying this piece to the base of the cage. The rope could no longer be pulled out of the cage to retrieve the meat, which was not obvious by visual inspection (see Fig. 2). If during the blocked trial, the dingo became distracted from the task, E1 placed the dingo back in the starting position and oriented it towards the cage. Dingoes were given two minutes to undertake the blocked (unsolvable) trial, but trials were aborted earlier (average trial length was 105 s, see Table 2 for trial lengths) if the dingo lost interest in the task (i.e. was not paying any attention to the task) and/or persistently struggled to get off the leash. This was determined on a case-by-case basis (i.e. no precise criterion was used to interrupt the trial).

This study replicated the methodology used by Miklósi et al. (2003), with a few minor exceptions. One less training trial was given in order to minimise risk of satiation or loss of interest in dingoes, since they quickly mastered the task (see latencies in Fig. 3). Minor differences in the size of the apparatus including the cage used by Miklósi et al. (2003) (cage of identical size was not available, 100 cm × 50 cm × 50 cm compared with this study 90 cm × 60 cm × 66 cm) and the length of the rope used (10 cm longer in this study).

The same two experimenters were present during all trials. E1 managed the dingo, whilst E2 placed food reward and doors into correct position, tied down the rope for the blocked trial, provided instruction, and recorded each trial using a video camera (Panasonic HDC-SD9). The video camera attached to a tripod was positioned 2 m to the side of the cage. The dingoes had not eaten for at least 6 h prior to testing.

Scoring and analysis

Latency to obtain the food reward was recorded for all trials. Latency was defined as the time elapsed between E1

Fig. 2 During the blocked trials, the rope was tied to the base of the cage with a second piece of rope (*left*). A piece of wood was then slotted into place in order to hide the attached piece of rope (*right*). This resulted in a task that appeared visually similar to the training trials

allowing the dingo to approach the rope and when the dingo touched the food reward with its mouth. For the blocked trial (trial 6), each instance was recorded if a dingo looked back at E1, who was standing directly behind the dingo throughout the trial. A look back event depended upon the operational definition used (see methods for Study 1 and Study 2). Every time a dingo *looked back*, the latency to look (i.e. time between the task beginning and the dingo orienting its gaze towards any part of E1's body) was recorded, as was the duration of the gaze.

Data were coded from videotapes of the trials by a single observer (B.S). In order to ensure inter-observer reliability, videotapes of 14 trials (7 training trials and 7 blocked trials) out of 72 were randomly selected, representing 20 % of the data, and coded by an independent observer, naive to the hypotheses of the experiment. Inter-observer reliability was high (Cronbach's α greater than 0.8) for the three measures: (1) latency or time elapsed between E1 releasing the dingo and the dingo retrieving the meat in the training trials; (2) latency or time elapsed between E1 releasing the dingo and the dingo making a *look back*; and (3) duration of the *look back* in the blocked trials.

The Shapiro–Wilk test for normality revealed that the data were normally distributed, thus parametric tests were appropriate for data analysis.

Study 1a

Definition of looking back

In line with Miklósi et al. (2003), looking back in Study 1a was operationally defined as the dingo turning its head to its side with its head/nose oriented towards any part of the caretaker/owner's body (p. 766).

Results

Training trials (trials 1–5)

During the first training trial (following the initial familiarisation period), the dingoes ($N = 12$) retrieved the reward in an average of 14.36 (±2.99) s, and by the fifth trial, this latency dropped to an average of 4.35 s ± 0.36 (see Fig. 3). A repeated measures one-way ANOVA was used to analyse the performance across training trials. Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(9) = 28.40$, $p < .05$, therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .40$). The results showed that there was a significant effect relating to trial chronology, where the mean latency for obtaining the reward significantly decreased over the five trials, $F\ (1.62, 17.77) = 7.54$, $p = .006$. Multiple pairwise comparisons (using Bonferroni corrections) revealed that trial 1 and trial 2 were significantly higher than trial 5. The third and fourth trials did not differ significantly from the fifth trial (Fig. 3).

During the training trials, the dingoes used their mouths/teeth to pull the rope and attached meat towards them. Although a large knot had been provided for the dingoes to grip at the end of the rope, no dingo used it. Instead, they typically grabbed the rope close to the edge of the cage. Sometimes two attempts were required to fully retrieve the piece of meat over the 30-cm distance. No dingo used its paws to hold down the rope or attempt to retrieve the meat.

Blocked trial (trial 6)

During the blocked trial (trial 6), the dingoes were given 2 min to complete the trial. Only 3 of the 12 trials lasted for 2 min because the dingoes quickly lost interest in the task or became distracted (average trial length 90.83 ± 6.99 s).

Table 2 Details from the blocked trial (trial 6) using Miklósi et al. (2003) definition (study 1), including the length of the trial in seconds (s), latency to look back at the experimenter (first and subsequent times) and the duration of the look

Dingo	Trial length (s)	Latency to look (s)	Duration of look (s)	Notes of behaviours observed
Tubby	80	–	–	No look back made to E1 during trial. After attempting to pull rope, dingo tried to get around to the sides of the cage and dig at the rope. Spent considerable time trying to get off lead (vigorous thrashing and jumping around).
Wirra	80	–	–	No look back made during trial. Dingo pulled continuously on rope for 30 s before trying other options. Lost interest in task at approximately 1 min
Nutmeg	106	–	–	No look back made during trial. Dingo spent time between bouts walking around and struggling with leash. Ended trial chewing on leash
Tele	120	–	–	No look back made during trial. Towards end of trial dingo spent a lot of time struggling to get off the leash. Ended trial chewing on leash
Solo	75	65.0[a]	0.3	Dingo looked back at E1 whilst the leash was restricting movement. Persistently pulled on rope throughout trial
Snapple	114	**49.0**	1.5	Tried to pull rope and go to the sides of cage for 45.8 s before looking back and then showed no interest in the task Referential gesture according to study 2 (task–human)
Uno	120	58.7[a]	0.2	The first occasion, the look back occurred when attempting to get off the leash. The long look back occurred when the dingo was not directed at the task
		64.5	2.3	
		114.0	0.7	Referential gesture according to study 2 (task–human)
		119.0	0.5	
Fanta	120	23.0[b]	0.7	First looked towards E2 and then made multiple short look backs to E1. Tried to walk around cage between bouts of pulling at the rope. The fifth look back occurred whilst struggling with the leash (and biting it) Referential gesture according to study 2 (task–human)
		27.7	0.2	
		48.1	0.4	
		52.4	0.5	
		56.0[a]	0.5	
		85.0	0.4	
Max	135	13.0[b]	1.3	Looked in direction of E2 after 13 s. Never showed any real interest in manipulating rope and obtaining food reward. Looked back at 58 s for 2 s in reaction to E1 moving and reaching down to move dingo back into starting position
		58.0	2.0	
Rosie	104	37.3[a]	0.5	Spent considerable time struggling to try and get off the leash. Made a glance up to E1 whilst turning around. Looked at E2 at 68 s. Looked at E1 when E1 was bent over behind the dingo attempting to reposition the dingo to the starting position
		68.0[b]	1.3	
		81.0[b]	1.1	
Tinky	102	22.4[a]	0.5	Look back occurred when turning around trying to get off leash. Used paws a lot to dig and pull rope
		26.4[a]	1.5	
Petal	109	53.0[a]	0.2	Look occurred whilst jumping around trying to get off leash. At 73 s thrashed again to get off lead (and biting leash). When pulling the rope failed, tried other methods such as going to side, biting cage and trying to get on top of the cage. Note, cage was moved during trial due to dingo pulling on rope
Overall Mean (SD)	105.42 (18.66)	56.08 (28.41)	0.83 (0.62)	
Study 1 Mean (SD)	–	40.18 (19.12)	0.84 (0.66)	
Study 2 Mean (SD)	–	82.67 (32.56)	0.78 (0.50)	

Additional descriptions of behaviours observed during this trial are also provided

For or latency to look column: bold indicates that the look back meets our operational definition (study 2)

[a] Indicates dingoes *looked back* to E1 according to the Miklósi et al. (2003) definition, but whilst attempting to escape from the leash (non-task directed)

[b] Indicates dingoes *looked back* to E1 according to the Miklósi et al. (2003) definition, but when looking at E2, who was positioned to the side (non-task directed)

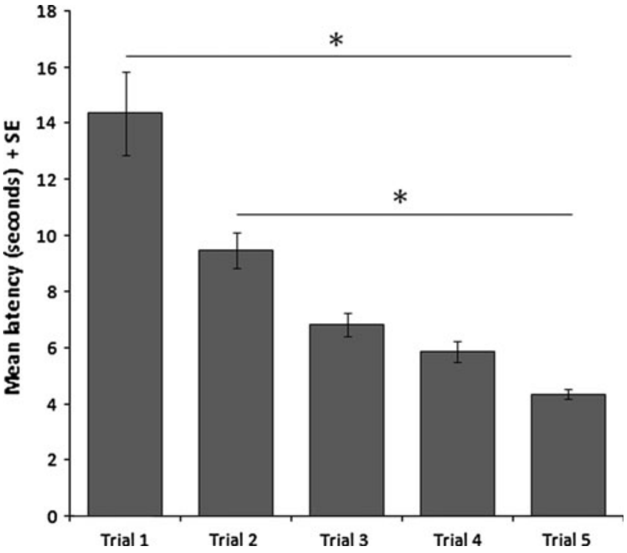

Fig. 3 Mean latency in seconds (±SEM) to obtain the food during training trials 1–5. * indicates significantly different at $p = < .05$

In the blocked trial, four of the 12 dingoes did not look in the direction of E1 at all, 6 looked back once, one three times, and one twice. These first *looks* occurred on average 43.14 ± 5.22 s after the trial began. The average length of these gazes was 0.76 ± 0.22 s. See Table 2.

When the trial was blocked, the dingoes' behaviour appeared to move through three distinct stages. Firstly, they attempted to pull on the rope as for the previous training trials, but without success. Secondly, they walked around to the left and right of the cage (they could not go too far as they were being held on a leash), with most returning to the rope and attempting to pull at it in short bouts (trying other methods and then going back to pulling). Others returned to the rope and pawed or scratched at it. Following this second stage of attempting alternative methods of reaching the meat, most of the dingoes then tried to free themselves from the leash. This included spinning around, chewing the leash, leaping, and more generally struggling whilst E1 remained passive. At times, these attempts to get off the leash were so vigorous that they could be described as *thrashing around*. Whilst struggling to get off the leash, dingoes occasionally glanced back towards E1 (also recorded as looking back although these looks were not considered as obvious references for help in the task). These stages or phases of the dingoes' reaction to the blocked rope can be described in terms of extinction processes that occur when a response is no longer rewarded. For example, (1) Persistence of the learned response. (2) Increase in the behavioural variability, and (3) A decrease in the operant response and the interest in the task.

Three possible categories of *looking back* (mutually exclusive) were discovered in this study. These included:

1. *Task-directed looking back:* This type of gaze occurred when the dingo attempted to solve the problem in the experimental setting and after discovering the task was no longer solvable, made eye contact with/looked towards the nearby human (presumably for assistance). The sequence of looking events was task–person or task–person–task. This type of gaze is considered referential.
2. *Non-referential looking back:* It is likely that the dingo (a social species) in an experimental setting made eye contact with humans in the immediate area as part of the process of gathering information about what the experimenter was doing. Unless a gaze occurred during the direct act of trying to solve the problem/task (as described in *task-directed gaze*), any non-context-specific gazes should not be considered referential in nature.
3. *Leash looking back:* When using the restraint (leash), a look back was directed towards the person holding or controlling the restraint as the dingo struggled to free itself (i.e. a *leash gaze*). A look back in this context can be considered referential as the dingo could not free itself without assistance. However, this type of gaze is a confounding variable and should be treated separately in experimental tasks such as the rope task (unless the actual experiment is looking at escape behaviour).

Study 1b

During Study 1a, we discovered that an ambiguous definition of gazing in the context of retrained animals, such as those described by Miklósi et al. (2003), might artificially increase the number of *looking back* events, since the animals may be *looking back* for other reasons than seeking assistance for the experimental task. In Study 1b, we attempted to establish an appropriate operational definition of referential gazing or *looking back* behaviour during a problem-solving scenario. Since the leash-directed gazes were likely to be associated with the task of *escape* from the leash, these were omitted from the data analysis. Using the new operational definition, a separate analysis of the same data was undertaken in order to represent a more accurate account of looking back behaviour in dingoes. There was no need to reanalyse data for the dingoes, which did not *look back* at all (i.e. Tubby, Wirra, Nutmeg, and Tele; see Table 2).

Operational definition of looking back behaviour in the rope-pulling task

Looking back during the rope-pulling task involves the dingo standing/sitting/lying in a stationary position (there may be some movement), and after first looking at or orienting its head/nose towards the task, the dingo then lifts or turns its head/nose and orients it towards the human experimenter's/caretaker's (holding leash, positioned behind the dingo) head/face for at least half a second. After *looking back* at the human, the dingo may orient its head/nose back to the task or may not (i.e. task–person or task–person–task). The *looking back* behaviour only occurs in the context of solving the rope-pulling task and not when attempting to escape from the leash or experimental situation (or other context). The term *gaze* is not used, as it is not always possible to determine the direction of the eye gaze, only the orientation of the head/nose.

Results

In the blocked trial, using the operational definition specific to the rope-pulling task (as just described), only three of the 12 (25 %) dingoes were found to have made true referential look backs. That is, five of the dingoes found to have looked back in study 1a did not meet the new criteria. All three of these dingoes first looked towards the task before looking back towards the experimenter (task–human-directed gaze). The average duration of these gazes was 0.78 s (range 0.4–1.5 s), with only one dingo looking back at the human for longer than one second. See Table 2.

Discussion

The dingoes in this study (mostly female), quickly learned how to retrieve the reward by pulling on the rope with their mouths. During training trials, as with dogs and wolves in the Miklósi et al. (2003) study, the mean latency to obtain the reward significantly decreased over the five trials. This suggests that dingoes quickly mastered the task, being both physically capable of retrieving the reward and sufficiently motivated to do so. Unfortunately, Miklósi et al. (2003) did not report the latency to retrieve the reward for the wolves and dogs for any of the six training trials. They merely comment on the fact was that there was no significant difference between the performance of wolves and dogs during training trials. It comes as no real surprise that all three canid species easily mastered this task, as problem-solving situations that require rope pulling or manipulation have been observed in both non-experimental captive settings (e.g. Fox 1971; Mech 1991) and in controlled captive experiments (e.g. Frank and Frank 1985; Hemmer 1983/1990; Hiestand 1989; Miklósi et al. 2003; Osthaus et al. 2005; Range et al. 2012; Scott and Fuller 1965).

Using the Miklósi et al. (2003) definition in Study 1a, over half of the dingoes looked back at the human experimenter at some point during the blocked trial (this included any time that the dingo made a *look back* to the experimenter throughout the trial). Overall, dingoes looked back earlier than either dogs or wolves in the Miklósi et al. (2003) study, but their gaze duration was fleeting in nature, thus more closely resembling wolves—although we understand direct comparisons are problematic, given slight variances in the methodology used and rearing history of the animals. Domestic dogs have also been reported to *look back* in the solvable trials (e.g. Marshall-Pescini et al. 2009), however, dingoes in this study did not.

Three fundamental problems were found with this study. Firstly, it was evident that problem-solving strategies between dogs and dingoes may be fundamentally different, and the rope task does not allow for these different strategies to be employed. Secondly, the use of a leash with wild animals may change the task from its intended purpose to an escape task. Thirdly, the operational definition of the looking back gesture appears to be insufficiently detailed.

Difficulties comparing the problem-solving strategies between wild and domestic canids

Most dingoes in this study at some point gave up trying to retrieve the reward. This occurred after attempting to use the initially successful strategy, then attempting alternate methods (unsuccessfully), and finally being unable to escape as the leash being held by the experimenter. The length of the blocked trials falls between the ones reported for dogs (60 s) and wolves (120 s) by Miklósi et al. (2003). The handlers in their study were instructed to hold the leash and stand motionless during the 2-min trial. When the wolves and dogs realised they could not obtain the reward, they lay down or attempted to leave the area (however, were unable to do because they were restrained; Personal Communication, Eniko Kubinyi). It would be unlikely that the wolves would spend the full 2 min continuously pulling or digging at the rope without trying any alternative strategies, since it would be a waste of energy to continue utilising an ineffective strategy. In our study, only when the dingoes had *given up* on the task (i.e. would not cooperate) was the trial ended by the experimenter. It is possible that the number of *looking back* gestures may have been greater had the blocked trials not been terminated, particularly if the dingoes continued to struggle to get off the lead. During the trials, the experimenters repeatedly placed the dingoes back at the starting position in front of the rope. However, any attempt at coercion or *forcing* the dingo to continue with the trial for the full 2 min set for each trial, would create too many extraneous variables, and subsequent look backs could then be attributed to more than just assistance on the task (and include others like frustration for being man-handled and forced to remain in one location). Thus, although dogs might quickly seek help from a human nearby, wild canids often continue to seek solutions independently. A look back is most likely to occur after all strategies have been exhausted. By not allowing all strategies to be tested, wild canids may become frustrated.

Another issue is with interpretation of results since prior experience of the animals may have influenced their behaviour during the task. That is, the rearing environments of dogs and wolves influence their problem-solving strategies. For example, some dogs may have extensive experience with their owners solving problems for them, whereas wolves have more experience solving problems on their own with little or no assistance from humans. Therefore, dogs may be reinforced during difficult problems when looking at their owner, whereas wolves learn that persistence generally pays off. Experience with humans and training in tasks that require watching human-related cues clearly plays a role. Marshall-Pescini et al. (2009) replicated the rope task experiment with dog breeds of varying levels of training and found that those trained to pay attention to human cues gazed longer during unsolvable problems. Wolves have been shown to be able to follow human gazing (Range and Viranyi 2011) and other human-directed behaviours performing at a similar level to dogs if reared under certain conditions (such as those in place at Wolf Park, implemented by Klinghammer and Goodman 1987, as cited by Udell et al. 2008, 2011, 2012).

The use of a leash (restraint)

Wild animals, particularly canids, do not react positively to being restrained (e.g. placed on a leash). For some dingoes, the rope task may have represented an escape task rather than a problem-solving task. Glances or look backs made by dingoes in this task occurred primarily when struggling to get off the lead, perhaps a reflection of an innate escape response to restraint (Packard 2003). Frank and Frank (1983) tested wolves on various cognitive tasks and found that when restrained by a leash, wolves responded in an emotional way that seemed to interfere with their performance on standardised tests. Miklósi et al. (2003) do not mention whether the wolves or dogs tested ever struggled to get off the leash. When using a restraint, it is difficult to understand the communicative behaviour of the dingoes. When an animal is exposed to an aversive stimulus, like a leash, a lot of appetitive behaviours may be inhibited related to the opposite motivational system (e.g. escape). The dingo is likely to have been focused on the leash and the unavailable reward irrelevant in this context. Ideally, dingoes (or other wild canids) and domestic dogs should be tested without restraint for comparative studies, since the leash is considered to be much less aversive for dogs than for dingoes (or other wild canids). As this study set out to replicate the methods used by Miklósi et al. (2003), only dingoes were used and they were restrained. Future studies should address these shortcomings.

Although we suggest that the use of restraints be avoided (given that wild animals, particularly canids do not react positively to being restrained, increasing the likelihood of leash gazes), occupational health and safety regulations/risk assessments/insurance regulations/zoo or sanctuary policies and procedures for humans may prevent this from occurring (as was the case in Australia where this study was conducted). If restraints are used, leash gazes must be taken into account when coding the data. An alternate method might be testing through fences (i.e. protected contact; Szokalski et al. 2012). Whatever method is used, all species being tested should be subjected to the same methodology (e.g. both tested with restraints or both tested through fences).

Problem with the operational definition of 'looking back'

Some problems with the operational definition of looking back have emerged. In their paper, Miklósi et al. (2003) do not include a discussion or hint of complications arising from restrained subjects or of other methodological issues, such as positioning of humans. They argue that because the human/caretaker is positioned 1 m behind the dogs, subjects have to turn around physically, and therefore, any glance backwards is a referential gesture. However, this only applies to canids that complete the task in an *ideal* way— it does not account for other circumstances in which a glance may be made. In our study, dingoes sometimes looked back (fleeting glances) at the experimenter whilst they attempted to get off (escape) the leash or walked around the space near the task (and therefore were not oriented towards or focused on the task). Miklósi et al. (2003) do not provide duration for the *look back* before being considered a referential gesture. This may be important, as a brief glance may not indicate *seeking help*, but may be providing the canid with information about what the experimenter is doing. A true referential gesture should be more than just a fleeting glance. It is uncertain whether the look backs observed in 7 of the 12 dingoes in study 1a are referential gestures. Thus, one of the biggest problems with studies that measure looking back behaviour is the operational definition itself.

An additional problem with studies looking at gazing behaviour in canids (including the present study) is the lack of a suitable control. It would be interesting to determine how often animals look back at their mothers or other conspecifics in a comparable task. This might be achieved by allowing a small group of dingoes to attempt to solve the task on their own without seeking assistance from a human. However, this would not answer the question of whether they look back for assistance from humans. Further research is needed to determine how long a referential gaze should be, and a standardised operational definition should be developed.

After developing and applying a more accurate (context specific) operational definition of *looking back,* we found that dingoes do not look back at humans for assistance during times of uncertainty or when confronted with a difficult problem. Instead they behave in a similar way previously reported in wolves (Miklósi et al. 2003). Our new operational definition seems to provide a more accurate indicator of looking back, and although context specific (to the unsolvable rope-pull task), we feel that it may be relevant for other problem-solving scenarios. Although the operational definition included the possibility of alternation between task and person or gaze alternation, no instances of alternation were recorded. Dingoes *looked back* at the human but did not then orient their head/nose back to the task. Studies which report *gaze-alternation* behaviour have tested domestic dogs, particularly those trained for *work*, such as search-and-rescue dogs (Marshall-Pescini et al. 2009). Thus, it is unclear whether alternation of *gaze* is influenced by training or as a result of the process of domestication.

Future directions

Many questions emerge as a result of the methodological issues related to the rope task experiment, but by using more accurate operational definitions of canid gazing behaviour, as we have provided, future studies may allow cross-species comparisons to be made (e.g. other populations of wolves and dingoes, other non-domesticated canid species such as foxes, and feral/wild domestic dogs that have limited learning experiences with humans). Future studies should also provide more detailed and clear reporting of results (e.g. raw scores), behavioural descriptions of participants during testing, information about the context in which participants look back, how many times they look back, and behavioural sequences during blocked trials.

Without adherence to standardised operational definitions, it is too early to determine whether there are reliable differences between species on *looking back* during problem-solving tasks. For the rope-pulling task at least, it is clear that dingoes should not be tested when they are restrained, as they do not appear to *look back* for help in solving the task.

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Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards All methods comply with the current laws of Australia (IMVS Animal Research Committee, project number 121/07).

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