

## **Do Domestic Cats (*Felis silvestris catus*) infer Reputation in Humans after Direct and Indirect Experience?**

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Although felids in general tend to be relatively asocial, domestic cats live closely with humans and other domestic species and thus, might be expected to respond to cues indicating, for example, the reputation of others. Furthermore, recent research with other less social species suggests that social learning is not unique to group-housed animals. Therefore, here we tested seven cat dyads with one cat interacting directly with unfamiliar humans, and another indirectly observing the interactions, to determine whether they would learn the ‘friendly’ and ‘aggressive’ reputations of the unfamiliar humans. Cats did not show a tendency to interact less, or more cautiously, with aggressive experimenters based on contact duration and latency to approach. Cats that observed the interactions indirectly spent more time near both experimenters and approached more quickly on test trials compared to cats that directly interacted with the experimenters, but this may have been due to spending more time crated between trials. We hesitate to conclude that cats are incapable of inferring reputation based on this small sample. It is possible that cats would behave more discriminately if tested in familiar environments.

Keywords: domestic cat, reputation, image scoring, social learning, eavesdropping

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Social learning broadly encompasses the transfer of information between individuals, either through observation or direct interaction with the outcomes of others’ actions, resulting in recognizable changes in the behavior of the observer (Heyes, 1994). Social learning affords animals a means to obtain valuable information through observing or interacting with other individuals, thus eliminating the need to undergo potentially costly and time-consuming trial and error learning (Heyes, 1994). Information including where to live,

who to mate with, what foods are safe to eat, who is a predator, and how to interact with others can be provided socially (Heyes, 2011). Reputation refers to characteristics or behaviors ascribed to an individual without requiring the opportunity to interact with that individual directly; thus, constituting a specialized type of social information transfer. For example, students may decide which courses to register for based on an instructor’s reputation among previous students and documented on websites such as Rate My Professor.

Due to an implicit assumption that social learning is primarily an adaptation to group-living (Heyes, 2011), researchers predicted that animals with a gregarious lifestyle would depend on social learning more than solitary species would (Klopfer, 1959; Reader & Lefebvre, 2001). This suggestion that social learning evolved as an adaptation to group living assumes that there must be different mechanisms mediating social learning compared to individual or asocial learning, and that they have evolved many times as specializations for group living across a wide range of taxa (Heyes, 2011). However, studies that have attempted to examine the effect of sociality on social learning capacities have largely been confounded by interspecific individual learning differences (Reader & Lefebvre, 2001). A finding that one species is a comparatively superior social learner holds little significance if that same species also proves to be a superior individual learner. In fact, when investigating social learning in feral pigeons (*Columba livia*) and zenaida doves (*Zenaida aurita*), species from the *Columbidae* family with similar ecologies but different social organizations, the more social pigeons outperformed the doves in both social and asocial learning. This finding suggests that these species differ in a general capacity to learn, not specifically through a social modality (Lefebvre, Palameta, & Hatch, 1996).

Furthermore, studies showing that solitary species can learn socially contribute to the notion that social organization and social learning abilities may be unrelated. For example, red-footed tortoises (*Geochelone carbonaria*), a non-social reptile that does not form permanent social groups or offer parental care, were able to successfully complete a detour task, but only if they observed a trained conspecific perform the task (Wilkinson, Kuenster, Mueller, & Huber, 2010). Similarly, largely solitary and

territorial bearded dragons (*Pogona vitticeps*), after witnessing a trained conspecific open a wire door by sliding it to the side with its head, were also able to open the wire door. Subjects that were not afforded the opportunity to watch a conspecific complete the task were not able to do so (Kis, Huber, & Wilkinson, 2015).

Heyes (2011) argues that social learning is not a separate learning capability limited to species that have experienced the pressures of group living, but instead social and asocial learning abilities depend on the same basic cognitive mechanisms. These associative mechanisms allow for the detection of predictive relationships in all natural domains, including when the input is derived socially (Heyes, 2011). As would be expected if the same associative learning principles underlie both asocial and social learning, three mechanisms of asocial learning (single stimulus learning, stimulus-stimulus learning, and stimulus-response learning) occur under similar conditions to their correlates in the social learning realm (Heyes, 2011). The evidence that asocial and social learning co-vary, that solitary species are capable of learning socially, and that the general principles of associative asocial learning can be applied to prominent forms of social learning, offer compelling evidence that the capacity for social learning is not a unique adaptation to group-living. Instead, it is possible that the same learning mechanisms underlie performance in both social and asocial species, but, social species have evolved a predisposition to attend to social cues. Thus, research investigating social learning need not be limited to species that adapted to live in complex social groups, but researchers may still detect differences in sensitivity to particular types of cues, such as facial expressions.

Social eavesdropping is considered a type of social learning, occurring when a bystander extracts information from the

signaling interactions between two or more individuals, which may involve auditory, visual, olfactory, or signals from any other modality (Shettleworth, 2010). Eavesdropping can be identified when the individual observing the third-party interaction alters its future behavior towards an individual involved in the interaction, but not towards a novel individual (Bonnie & Earley, 2007). Eavesdropping individuals may acquire information about the individuals involved in the interaction as unique animals, about the relationship between the individuals involved, and potentially about the relationship between those individuals on a larger social framework (Cheney & Seyfarth, 2004). Eavesdropping can provide a rapid and safe way to obtain information, and as a result, it may be widespread throughout the animal kingdom (Doutrelant & McGregor, 2000).

One such type of information that can be obtained through eavesdropping is the reputation of others (i.e., basic characteristics and dispositions), allowing observers to make predictions about the future behavior of the observed individuals (Chijiwa, Kuroshima, Hori, Anderson, & Fujita, 2015). Reputation judgments involve the capacity to assign stable characteristics and dispositions to individuals in a variety of domains (Subiaul, Vonk, Okamoto-Barth, & Barth, 2008). It is thought that humans possess the most fluid ability to attribute reputations, and that this skill has been of particular importance in forming and maintaining humans' extensively cooperative societies (Chijiwa et al., 2015). Reputations can be formed either through direct experiences, or through observation of third-party interactions, as in social eavesdropping (Subiaul et al., 2008). Although first-hand experiences provide the most reliable source of information, having the capacity to predict the behavior of other individuals based on third-party interactions can be extremely

beneficial, when direct experiences could be risky (Peake, Terry, McGregor, & Dabelsteen, 2002), such as when evaluating the relative dominance or fighting ability of another individual (Subiaul et al., 2008).

The capacity to socially eavesdrop has been investigated in a variety of species (e.g., Siamese fighting fish: Doutrelant & McGregor, 2000; Oliveira, McGregor, & Latruffe, 1998; red-winged blackbirds: Freeman, 1987). However, the focus has been on eavesdropping in the contexts of dominance assessment and mate choice, so these domain-specific instances of eavesdropping might not represent an underlying capacity for these species to form reputations in a variety of contexts (Marshall-Pescini, Passalacqua, Ferrario, Valsecchi, & Prato-Previde, 2011). These domain-specific skills function comparably to true reputation judgments, yet potentially lack the flexibility of a mechanism that can form reputation judgments based on a wide range of social information (Subiaul et al., 2008). Because mate choice and dominance assessment comprise two domains where accurate evaluation is vital for survival, it may not be surprising that reputation judgments evolved in these settings in a plethora of species. Evidence of social eavesdropping in more abstract contexts, involving situations for which a given species has not evolved to assess the relevant features of conspecifics, would suggest the presence of a more domain-general reputation mechanism.

Domesticated dogs (*Canis lupus familiaris*) and cats offer an opportunity to assess social eavesdropping abilities in contexts that are not as intimately intertwined with their ancestors' evolutionary histories. If the ancestors of domestic dogs and cats possess a domain-general reputation mechanism, we might expect to see this capacity extend to forming reputations about humans as well. Therefore, research examining the extent to which these

eavesdropping abilities that result in reputation-like inferences generalize to other contexts will aid in providing a predictive theory for when and how reputation attribution will occur.

Some work on this front has already begun through research with domesticated dogs. Rooney and Bradshaw (2006) offered evidence that dogs use third-party interactions to make reputation judgments using the presence or absence of play signals in a human-dog tug-of-war game. Dogs were more likely to approach winners (both human and dog) of the tug of war game when the interaction involved playful gestures emitted by the human, whereas they showed no preference for the winners when these play signals were absent. This finding demonstrates that dogs may use social eavesdropping to form judgments about both the type of interaction occurring, and reputations about the individuals involved. Marshall-Pescini et al. (2011) found that dogs also form reputation judgments about relative generosity based on third-party interactions between humans. After observing interactions with a selfish donor that refused to offer food to a begging human, and a generous donor that provided food, dogs were more likely to approach the generous donor in the testing phase. Importantly, a ghost control condition was conducted without a beggar present, to determine if the dogs were truly utilizing information provided by the interaction, or if they were simply responding to the positive/negative behaviors of the experimenters. Dogs in the ghost control group showed no preference for either the generous or selfish actors after observing them engage in the same behaviors in the absence of a beggar. Thus, it can be concluded that dogs are capable of using third-party interactions to form reputations in the context of food sharing (Marshall-Pescini et al., 2011; although see Nitzschner, Melis,

Kaminski, & Tomasello, 2012, Nitzschner, Kaminski, Melis, & Tomasello, 2014).

Despite the growing body of research on social eavesdropping in domestic dogs, domestic cats' abilities in this domain remain entirely unexplored. The body of research focusing on social information use in domestic dogs has focused particularly on dogs' sensitivity to human body language and attentional state, assuming these skills may present in part due to the 32,000 years of domestication dogs have undergone (Thalmann et al., 2013). Hare, Brown, Williamson, and Tomasello (2002) describe the possibility that the majority of dogs' sensitivity to human social cues can be traced to their phylogeny, where the thousands of years of their domestication have led to genetic changes enhancing this capacity. The so-called "Domestication Hypothesis" places little weight on the possibility that life experience and environmental factors may play a large role in dogs' capacity to react to human cues (Udell, Dorey, & Wynne, 2010). However, Udell et al. (2010) posit that dogs' acuity to human cues is a result of both phylogenetic and ontogenetic forces. Udell et al. (2010) propose the Two Stage Hypothesis, whereby an animals' ability to follow human social cues relies on a willingness by the animal to accept humans as social companions, which is typically established early in ontogeny, and secondly, requires that the animal has sufficient experience receiving reinforcement as a result of human movements (Udell et al., 2010). Thus, these criteria may be applied to any species, domesticated or not, to predict success in following human social cues.

Indeed, an experiment by Udell, Dorey, and Wynne (2008) comparing the performance of domestic dogs with that of wolves that had received equivalent socialization to humans, found that wolves outperformed dogs on a task requiring them to follow human point cues. Thus, despite

domestic cats' relatively more recent domestication, we expect to discover similar proficiency in using human communicative cues given proper socialization. Recent research examining social cognition in cats provides some support, with cats displaying equivalent abilities to follow human pointing gestures as dogs (Miklosi, Pongracz, Lakatos, Topal, & Csanyi, 2005), as well as comparable levels of social referencing to owners in an uncertain situation (Merola, Lazzaroni, Marshall-Pescini, & Prato-Previde, 2015; Merola, Prato-Previde, & Marshall-Pescini, 2012a; Merola, Marshall-Pescini, & Prato-Previde, 2012b). Cats have also been successful at following dynamic human gaze both with ostensive and non-ostensive cues (Pongrácz, Szapu, & Faragó, 2018).

In addition, although the domestic cat (*Felis silvestris catus*) is now the most popular pet in the world (Driscoll et al., 2007), resulting in access to large samples in a range of settings, domestic cats have most likely also been overlooked due to possibly erroneous assumptions about their asocial nature (although see Vitale Shreve & Udell, 2015). Although nearly all of the thirty-seven felid species are solitary as adults, tending to form strong territorial connections as opposed to bonds with conspecifics, free-ranging domestic cats have been known to form colonies within which they display preferences toward particular associates (Bradshaw; 2014; Izawa & Doi, 1993; Macdonald, Yamaguchi, & Kerby, 2000). Further, just as domesticated dogs have shown a sensitivity to human communicative cues (Udell et al., 2010), domesticated cats have demonstrated similar abilities, in regards to following human pointing gestures (Miklosi et al., 2005), distinguishing between human voices (Saito & Shinozuka, 2013), engaging in social referencing in uncertain situations (Merola et al., 2015; Merola et al., 2012a; Merola et al., 2012b), and

distinguishing between emotional states in their owners (Galvan & Vonk, 2016). Most relevant to the current study, domestic cats have been shown to learn via observation with observer cats learning more quickly to avoid an aversive stimulus than cats trained using shaping procedures (John, Chesler, Bartlett & Victor, 1968). Furthermore, kittens selectively acquired a lever pressing response after observing their mothers, but not a stranger cat, suggesting that observational learning may be facilitated by observing a familiar, possibly related individual (Chesler, 1969). Although domestic cats are not as solitary as their wild ancestors, they did not evolve to live in social groups. Thus, if they are capable of utilizing information gleaned via social eavesdropping to form reputation judgments about stable characteristics in humans, it will be informative with regard to the important role of ontogenetic experiences and genetic influences, versus evolutionary selective pressures in shaping this aspect of cognition.

The present study, therefore, aims to provide insight into domestic cats' capacity to utilize both direct experiences and third-party interactions, to predict future human behaviors. Cats were tested in dyads, with one serving as the direct experience participant (or demonstrator), and the other serving as the indirect experience participant that observed the demonstrators' interactions with experimenters through a one-way mirror. Cats in the direct experience group were exposed to two separate interactions with unfamiliar experimenters, while cats in the indirect experiment group observed through a one-way mirror. One of the experimenters engaged in a friendly/nonthreatening interaction with the demonstrator cat. The other experimenter (i.e., aggressive) engaged in a negative/threatening interaction with the cat. During experimental trials, cats were exposed to the friendly and aggressive

experimenters separately engaging in neutral behavior. We predicted that cats would exhibit more positive behaviors, approach more quickly and spend more time in contact with the friendly experimenter, compared to the aggressive experimenter.

**Method**

**Subjects**

The subjects consisted of 13 domesticated cats (seven males and six females) paired into seven dyads (one cat played dual roles in two different dyads, see Table 1). Owners were recruited through online advertisement (i.e., social media and email) and through word of mouth. All cats were required to have proof of a current rabies vaccination that occurred at least two weeks prior to testing as well as a pet carrier

with a non-opaque door (e.g., clear or mesh) to allow the observer cat to watch activity outside of the carrier. Cats ranged in age from 1 year 3 months to 15 years 6 months with an average age of 7 years 5 months. Cats from the same household were paired together, with the exception of dyad 7 who came from different households. One cat participated twice, first as the direct cat in dyad 5 and then immediately after as the indirect cat in dyad 6 (Table 1). Owners were instructed that they could stop participation at any time throughout the experiment if it was determined that either cat was becoming too stressed. All dyads of cats completed all trials. The experiment took place from March to July 2017.

Table 1.  
*Subject Information.*

Dyad	Direct Cat	Sex	Indirect Cat	Sex
1	Juniper	M	Hendrix	F
2	Cady	F	Honda	M
3	Lucy	F	Hookah	F
4	Poe	M	Obe	M
5	Magic*	M	Hannah	F
6	Martin	M	Magic*	M
7	Marble**	M	Gypsy**	F

\*Participated twice, first as a Direct cat and then as an Indirect cat with a different partner.

\*\*Dyad does not live in the same household.

**Testing Environment**

The experiment was conducted in three adjacent rooms – the testing room, the observation room, and the hallway (Figure 1). Prior to testing, lines of tape were used to separate the floor of the testing room into nine equal-sized rectangles in a 3 x 3 format. The rectangles were approximately 1.22m by 1.07m. A Hero GoPro camera was mounted on the wall facing the experimenter to record all sessions for behavioral coding. A second GoPro camera was mounted on the wall facing the door as a back-up and to obtain a slightly different view of the testing room. A litter box was placed along the front wall next

to the door and a two-compartment bowl was set along the back wall, containing water and treats. The wall shared by the observation and testing rooms contained a large one-way mirror such that those in the observation room could watch activity occurring in the testing room while being invisible to those in the testing room. Against the far left wall of the observation room was a table such that the indirect cat, while in a carrier, could be set on the table facing the one-way mirror and be able to see clearly the activity occurring within the testing room. On the table, facing the door of the indirect cat’s carrier was a camera to record the position of the indirect

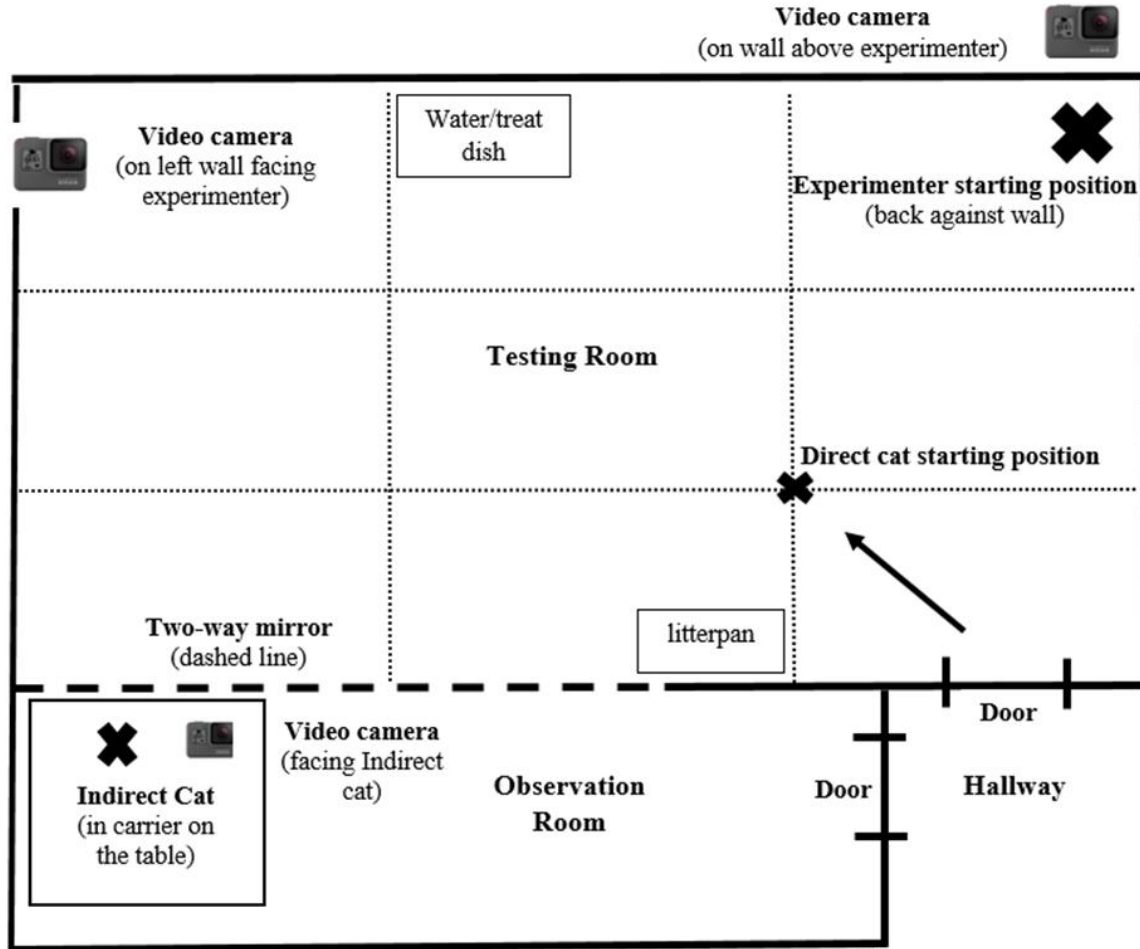


Figure 1. Diagram of testing rooms. During demonstration trials, the indirect cat was on the table in the observation room, as indicated above. For testing trials, the cat not being tested was in a carrier in the hallway while the tested cat was placed in the testing room

cat within the carrier. This was done so that we could corroborate whether the indirect cats were observing the interactions.

The doors for both the observation and the testing room led to a shared hallway. The owner stayed in this room during the experiment in order to easily retrieve the direct or indirect cat from the testing or observation rooms in between trials.

### Procedure

**Preliminary steps.** Testing occurred in the Psychology building at Oakland University in Rochester, Michigan. Subjects were transported to the testing location by their owners in individual pet carriers. Upon

arrival, each cat was placed in the hallway, still in their respective carrier. The owner was then brought to a separate room to complete a questionnaire regarding each cat's age, sex, and life history as well as an informed consent form. Proof of rabies vaccination for each cat was also collected at that time. Each cat was randomly assigned to either interact directly with the experimenters (direct) or to watch the interactions from behind the one-way mirror (indirect). Three experimenters participated in the study with two participating with a given testing dyad. Each experimenter was randomly assigned to act as the aggressive or the friendly experimenter

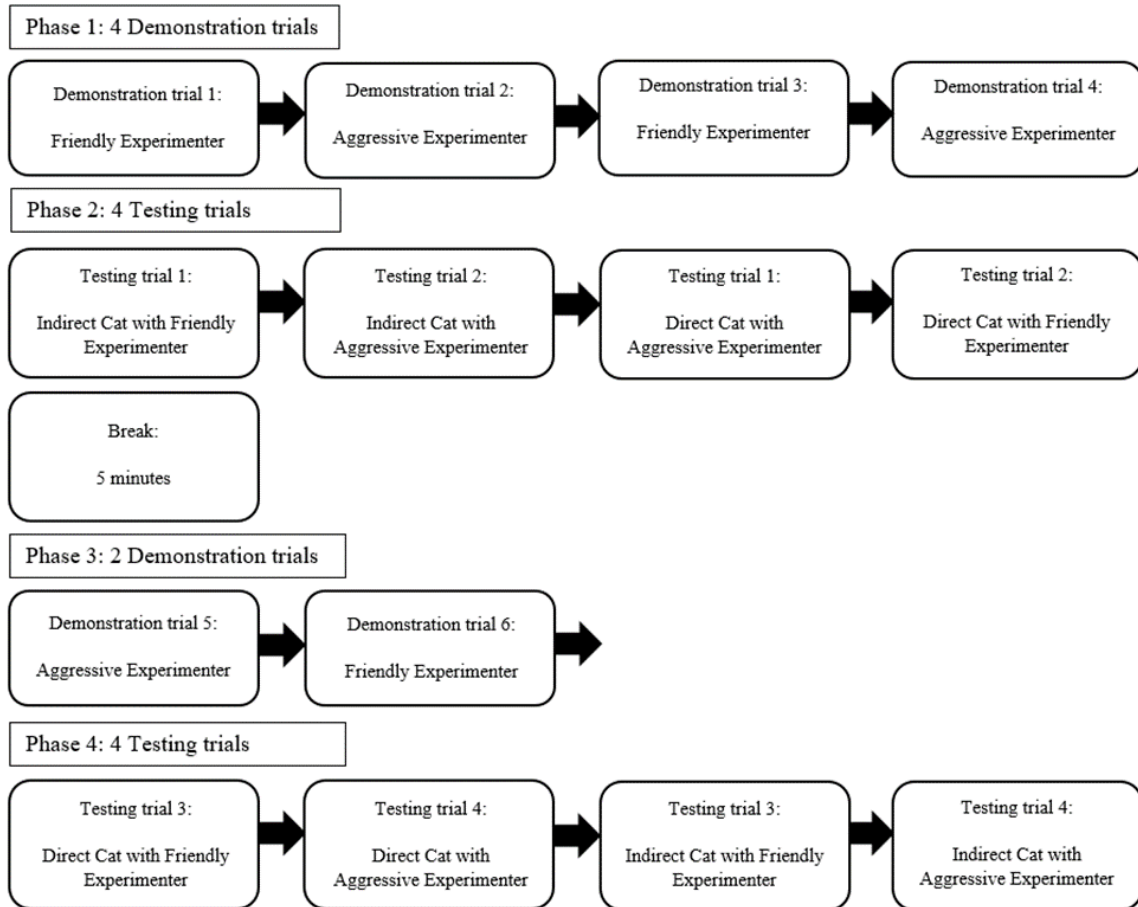


Figure 2. Flow-chart illustrating an example of experimental proceedings. The order of experience trials with the friendly or aggressive experimenters was counterbalanced across subjects.

for that dyad, ensuring across all testing dyads, each experimenter participated in each role approximately 50% of the time. All experimenters were female.

After the initial documentation was completed, each cat was given five minutes alone in the testing room, with access to treats and water, in order to acclimate to the testing environment. During acclimation, the cat not in the testing room remained in a carrier in the hallway. After each cat acclimated to the testing room, the cameras in the testing and observation rooms were turned on, and the treats were removed from the bowl (water remained).

**Testing.** Each dyad participated in one session consisting of 14 two-minute trials that were divided into two demonstration and two testing phases (see Figure 2). Phase 1

consisted of four demonstration trials in which the direct cat interacted with either the friendly or aggressive experimenter (two trials each experimenter in random order). Each trial lasted two minutes. Prior to a demonstration trial, the indirect cat, while in a carrier, was placed on the table in the observation room, facing the one-way mirror. The door was then closed and the owner remained in the hallway. An experimenter, either friendly or aggressive, then entered the testing room and sat with her back against the far wall while facing the door. Once the experimenter indicated they were ready, the owner placed the direct cat in the testing room on the marked starting point and then closed the door, remaining in the hallway with the second experimenter. The direct cat was then allowed to roam freely in the testing



room during the demonstration trial while the indirect cat had access to watch the trial from their carrier in the observation room through the one-way mirror. When the owner closed the testing room door, the experimenter in the hallway started the trial timer on the stopwatch.

Once the demonstration trial began, while remaining seated, the experimenter in the testing room utilized verbal and body language cues to act out the assigned role towards the direct cat. The experimenter assigned to the friendly role used soothing tones of voice, reached slowly towards the cat, and avoided prolonged direct eye contact during their demonstration trials while the experimenter assigned to the aggressive role used sharp tones of voice, quickly swatted their arm in a ‘go away’ motion, and maintained aggressive eye contact with the direct cat as it moved around the room as cats generally find prolonged staring intimidating (Crowell-Davis; 2007; Goodwin & Bradshaw; 1997). The experimenter did not make direct physical contact towards the cat but the direct cat could initiate contact through approaching the experimenter. Once two minutes had passed, the experimenter in the hallway knocked on the testing room door to indicate the demonstration trial had ended and the owner retrieved the direct cat from testing room and either held the direct cat in the hallway (if the next trial was a demonstration trial) or put the direct cat back in the carrier (if the next trial was a testing trial).

Phase 2 consisted of four testing trials in which both cats interacted with each experimenter separately, with the experimenter behaving in a neutral manner. Thus, each cat interacted with each experimenter for one trial, and the order in which the cats participated in a testing trial with each experimenter was counterbalanced across dyads. Prior to a testing trial, the carrier containing the indirect cat was

removed from the observation room and put in the hallway and the direct cat was placed in a separate carrier in the hallway, while the experimenters prepared for the next trial. An experimenter entered the testing room and sat with her back against the far wall while facing the door. Once the experimenter indicated she was ready, the owner placed either the direct or the indirect cat in the testing room on the marked starting point and then closed the door, remaining in the hallway with the second experimenter. The cat was then allowed to roam freely in the testing room during the testing trial while the other cat remained in a carrier in the hallway. When the door closed, the experimenter in the hallway started the trial timer on the stopwatch. Each trial lasted two minutes.

Throughout the testing trial, the experimenter did not engage in any verbal or body language cues associated with the assigned role. Instead, they remained seated with crossed legs and hands on the knees, looking forward towards the closed door with a neutral expression. Once two minutes had passed, the experimenter in the hallway knocked on the testing room door to indicate the testing trial had ended and the owner retrieved the cat from the testing room, placing the cat back in a carrier in the hallway. After Phase 2 was complete, there was a five-minute break in the session during which both cats were placed in their respective carriers and given some treats. The owner and the experimenters went to a separate room during the break to minimize each cat having exposure to the experimenters outside of the trials.

Phase 3 consisted of two reminder demonstration trials (one with each experimenter in counterbalanced order across cats), which were identical to those in Phase 1.

Phase 4 consisted of four testing trials that were identical to those in Phase 2 but presented in a different random order.

### Behavior Coding

A naïve research assistant coded the cats' behavior during the testing trials using a behavioral ethogram for domestic cats (See Appendix). A second naïve research assistant coded a randomly determined 16.67% of the trials for reliability. The coder indicated the presence or absence of behaviors in 10-second intervals.

Four variables were calculated for each cat for each condition: Latency to approach, time in contact, frequency of positive behaviors, and frequency of negative behaviors. Latency to approach was calculated by assigning the mid-point of the interval the cat first came in contact with the experimenter, as defined by one paw crossing a line of the taped gridlines within which the experimenter sat. For example, if the cat crossed the line during the first 10-second interval, it was calculated as a 5-second latency to approach for that trial. If the cat never came into contact with the experimenter, the latency to approach was set at the length of the trial (120 seconds). This helped to distinguish a cat who never came into contact versus a cat who first came into contact in the last 10-second interval (which would be assigned a 115 second latency to approach). An average of the latency to approach scores for both trials of a given condition (e.g., friendly experimenter) was then calculated.

Time in contact was calculated by multiplying the number of intervals a cat came in contact (again defined as having a paw cross a taped line within which the experimenter sat) by 10 seconds. For example, if the cat crossed the line during the three separate intervals, the time in contact score would be 30 seconds. If the cat never came into contact with the experimenter for a trial, the time in contact was set at 0. An average of the time in contact scores for both trials of a given condition (e.g., friendly experimenter) was then calculated.

Behaviors were categorized as either positive, negative, or neutral (determined prior to coding). Neutral behaviors were not included in analyses. For each condition (e.g., friendly), an average positive and negative behavior score was calculated as follows. The number of intervals during which a given behavior occurred was summed to create a subtotal for that behavior for that trial. The subtotals for all positive behaviors (and similarly for all negative behaviors) were summed within a trial to yield a final positive (or negative) behavior score for that trial. Across both trials for a condition, the positive (or negative) scores were then averaged.

A naïve research assistant also coded the amount of time the indirect cat spent facing the one-way mirror during the demonstration trials, as a means for assessing whether the indirect cat was attending to the social interaction between the direct cat and the experimenter. A second naïve research assistant coded 18.18% of the trials for reliability. During each 5-second interval of a trial, the coder indicated if the indirect cat was facing the one-way mirror at any point of the interval. The total intervals for the trial during which the cat was facing the one-way mirror multiplied by 5 seconds created a facing forward score for that trial.

### Reliability

We assessed inter-rater reliability by computing a Pearson's correlation coefficient for each of the four scores. Nine trials were included in the reliability calculations, which represented 16.67% of the coded data. A high degree of inter-rater reliability was found between the two coders for all four scores: Latency to approach ( $r = .992$ ,  $N = 9$ ,  $p < .001$ ), time in contact ( $r = .969$ ,  $N = 9$ ,  $p < .001$ ), positive behaviors ( $r = .847$ ,  $N = 9$ ,  $p < .05$ ), and negative behaviors ( $r = .971$ ,  $N = 9$ ,  $p < .001$ ). We also assessed inter-rater reliability by computing a Pearson's correlation coefficient for the time the

indirect cat spent looking in the direction of the one-way mirror during the demonstration trials. Eight trials were included in the reliability calculations, which represented 18.18% of the coded data. A high degree of inter-rater reliability was found between the two coders ( $r = .966$ ,  $N = 8$ ,  $p < .001$ ).

Data were analyzed with Mixed Model ANOVAs with experimenter (friendly or aggressive) type as the within-subjects factor and cat (direct or indirect) type as the between-subjects factor.

**Results**

**Indirect Cat Attention**

Cats could have spent a maximum of 120 seconds looking toward the testing room during the demonstration trials. Cats, on average looked forward for about 82 seconds of the trial, with looking behavior ranging from 0 to 115 seconds on any given trial. The cat that did not look at all for two trials with the angry experimenter also failed to approach the experimenters during testing, so was not included in analyses of approach latency or contact with the experimenter. Interestingly, this was the only indirect cat

paired with a direct cat that did not live in the same household, which may have contributed to the lower frequencies of watching it interacting with experimenters.

**Testing**

**Behavior.** A mixed-model analysis of variance with behavior (positive or negative) and experimenter (friendly or aggressive) type as the within-subjects factors and cat (direct or indirect) type as the between-subjects factor was utilized to assess whether the cats discriminated between the two experimenter types based on the rate of positive and negative behaviors. The only significant effects were a main effect of behavior type ( $F_{1,12} = 106.55$ ,  $p < .001$ ,  $\eta^2 = .90$ ) such that the cats exhibited more positive ( $M = 36.39$ ,  $SE = 1.60$ ) than negative behaviors ( $M = 14.05$ ,  $SE = 1.04$ ) overall, and an interaction between behavior type and cat group ( $F_{1,12} = 12.53$ ,  $p = .004$ ,  $\eta^2 = .51$ ). The data are depicted in Figure 3, which shows that both groups of cats showed more positive than negative behaviors, but the effect was much larger for the indirect cats. The interaction between experimenter and cat

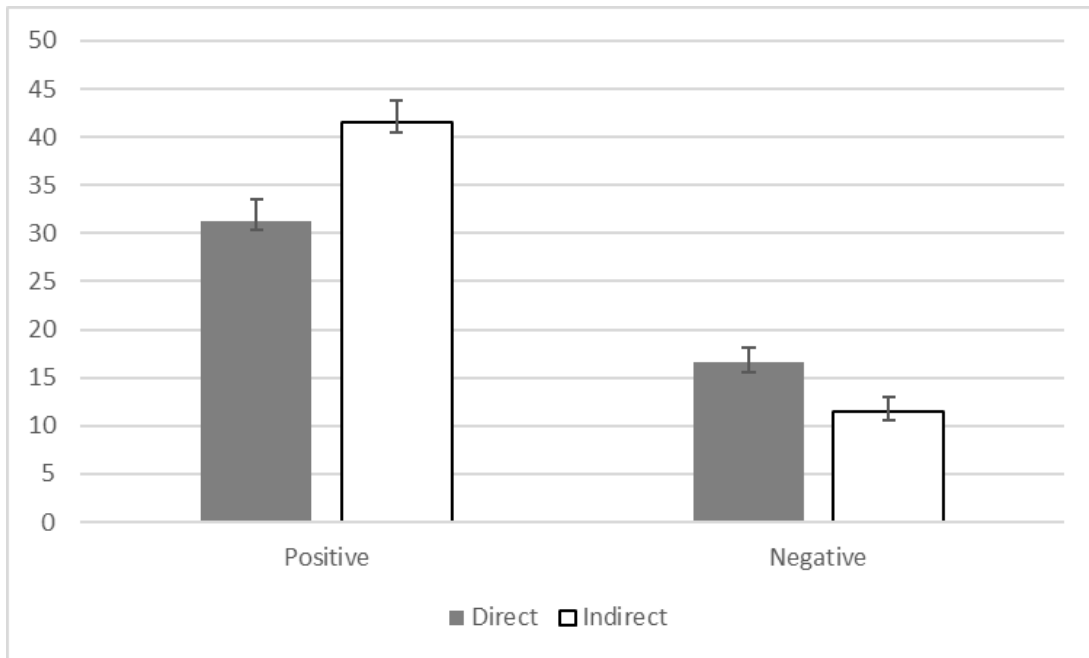


Figure 3. Interaction of cat group (direct, indirect) by behavior type (positive, negative)

group approached significance ( $F_{1,12} = 91.29, p = .065, \eta^2 = .26$ ). In order to probe the interactions further, separate ANOVAs were conducted by cat group. There was a significant effect of behavior type for the direct cats ( $F_{1,6} = 13.02, p = .01, \eta^2 = .69$ ), but no effect of experimenter. For the indirect cats, there was a significant effect of behavior type ( $F_{1,6} = 410.87, p < .001, \eta^2 = .99$ ), and experimenter ( $F_{1,6} = 24.86, p = .002, \eta^2 = .81$ ). In addition, the interaction between behavior type and experimenter approached significance ( $F_{1,6} = 5.20, p = .06, \eta^2 = .46$ ). The indirect cats were more likely to exhibit positive behaviors for the aggressive than the friendly experimenter, but did not show a difference in negative behaviors based on the experimenter.

**Latency to Approach.** Because a cat could choose to never come in contact with the experimenter, resulting in a 120 second latency to approach or a 0 second time in contact, those outlier scores were removed in these analyses, such that three direct and five indirect cats remained in the analysis. A mixed-model analysis of variance of latency to approach with experimenter (friendly or aggressive) as the within-subjects factor and cat (direct or indirect) group as the between-subjects factor revealed only an effect of cat ( $F_{1,6} = 5.87, p = .05, \eta^2 = .49$ ). Direct cats, on average, took longer to approach compared to indirect cats ( $M_s = 92.08$  versus  $43.75, SE_s = 11.17$  and  $12.22$ ).

**Time in Contact.** A mixed-model analysis of variance of time spent in contact with the experimenter with experimenter (friendly or aggressive) as the within-subjects factor and cat (direct or indirect) as the

between-subjects factor revealed only an effect of cat ( $F_{1,6} = 13.76, p = .01, \eta^2 = .70$ ). Direct cats, on average, spent less time in contact with the experimenter compared to indirect cats ( $M_s = 8.33$  versus  $37.00, SE_s = 6.11$  and  $4.73$ ).

When outliers are included in both the latency to approach and the time in contact analyses, the results do not change, except that, for time in contact, the effect of experimenter approaches significance with cats spending more time with the aggressive experimenter, ( $F_{1,6} = 3.92, p = .07, \eta^2 = .25$ ). Table 2 shows how many cats in each group failed to approach or contact the experimenter in both conditions. It was the same two indirect cats that consistently failed to approach or contact either experimenter. The direct cats paired with these two indirect cats also failed to approach or contact either experimenter, suggesting that perhaps cats from these two households were particularly shy in the experimental context. Of the other direct cats, two others approached or contacted neither experimenter. Two direct cats contacted the aggressive but not the friendly experimenter, and two other direct cats approached the aggressive but not the friendly experimenter.

**Discussion**

Our data does not provide evidence in favor of our expectation that domestic cats can attribute reputations to humans through direct interactions or through observing interactions between humans and conspecifics. Cats did not spend more time or approach more quickly when a previously friendly experimenter was present and behaving in a neutral manner, compared to

Table 2.  
*Number of cats from each group failing to approach or contact experimenter in both conditions.*

	Did not Approach		Did not Contact	
	Friendly	Aggressive	Friendly	Aggressive
Direct	6	4	6	4
Indirect	2	2	2	2

when a previously aggressive experimenter was present and behaving in a neutral manner. Nor did they exhibit more negative behaviors in the presence of the aggressive experimenter, or more positive behaviors in the presence of the friendly experimenter as expected. If anything, cats, specifically the cats that observed indirectly, appeared to show a weak preference for the aggressive experimenter. We think there are several reasons for these unexpected findings.

Given that the indirect cats spent significant time facing the one-way mirror, we feel reasonably confident that these cats watched the interaction occurring in the testing room between the experimenter and the direct cat. However, because social learning through social eavesdropping relies on the bystander extracting information about a social interaction from various cues (Shettleworth, 2010), the limited modalities available to the indirect cat may have had an impact on each indirect cat's ability to extract enough relevant information about the social interaction to ascertain a distinct reputation about each human experimenter. When in the observation room, the main information available to the indirect cat was visual in nature. Although auditory cues may have been available, they would have been muted through the wall and closed door, potentially limiting the ability to gain accurate and effective information aurally. Olfactory cues released from the direct cat would not have been available. Kittens are born lacking vision and hearing, but rely on tactile and olfactory information, which may suggest the importance of olfaction for cats (Bradshaw et al., 2012). In addition, in an observational study conducted on a free-roaming colony of cats, the most common behavior (out of 22) witnessed was sniffing another cat. In fact, sniffing accounted for 30.8% of the total behaviors (Shreve, 2014), further supporting the importance of olfaction in the social lives of cats. Therefore, future studies on social

eavesdropping in domestic cats should use a methodology that allows the bystander access to olfactory cues. It may be especially important for cats to interact with humans that are not just acting friendly and aggressive because acting is unlikely to reproduce the chemical cues that are present when individuals feel genuine emotions such as fear or anger (e.g., Fiaolová & Havlíček; 2012).

Although the limited modalities may have played a role, because the indirect cat was kept in a small closed carrier in order to help increase the likelihood that the cat would stay in front of the one-way mirror, such constrained movement during demonstration trials may have had the unintended consequence of increasing the indirect cat's movement and behaviors when allowed to roam in the testing room during test trials. This suspicion is corroborated by the finding that indirect cats approached more quickly and spent more time in contact with the experimenters compared to the direct cats, regardless of experimenter type. Even if the indirect cat had extracted enough relevant information to form reputations about both humans, the cats' desire to move freely and explore may have superseded such information.

For the direct cats, who did have access to various cue modalities, we also did not find the expected results. Instead, direct cats took longer to approach and spent less time in contact with both types of experimenters compared to indirect cats. This suggests the direct cats had an overall hesitation towards the experimenters throughout testing. Unlike the indirect cats, the direct cats had to be handled regularly (were picked up and placed in an unfamiliar testing room without the owner every two minutes for total of 10 trials compared to the four trials for the indirect cat). Further, the direct cat spent far less time in their carrier than the indirect cat, which may have been at

least a familiar space. The increased handling and time spent in an unfamiliar location without the owner may have resulted in the direct cats associating both experimenters with the negative testing circumstances, thus resulting in the general avoidance of both experimenter types. Future studies may be more successful if testing occurred in a familiar location, such as in the cat's home. Based on more limited experience compared to most dogs, cats are often not comfortable or familiar with novel testing situations, although here we needed to use the one-way mirror in the experimental rooms. In addition, test sessions might be better limited to single interactions rather than repeated trials.

When examining the positive and negative behavior scores, there is a slight indication that the indirect cats may have been able to distinguish between the two experimenters even though the results did not support our hypotheses. Indirect cats, regardless of behavior type, on average, exhibited significantly more behaviors when in the testing room with an aggressive experimenter than with a friendly experimenter. Further, there was an

interaction between the experimenter and the behavior type that approached significance, such that indirect cats exhibited a higher rate of positive behaviors for the aggressive than the friendly experimenters while exhibiting no difference in negative behavior rates between the two experimenter types. In order to portray anger, aggressive experimenters spoke louder and sharper and used quicker hand gestures than the friendly experimenters, which may have drawn more attention during demonstration trials. In turn, when the aggressive experimenter acted in a neutral manner during testing trials, this contrast in behavior from demonstration to test trials may have been starker than the change for the friendly experimenter, resulting in the indirect cats exploring more during test trials with the neutral aggressive experimenter. Although we do not feel comfortable attributing this to the formation of reputation, it does suggest that a future study that addresses some of the limitations outlined above, may see fruitful results. We hope that this preliminary set of findings will encourage others to continue to test various forms of social learning in other less social animals.

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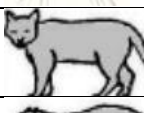





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Appendix A

Ears Forward	Positive	
Ears Out	Negative	
Ears Back	Negative	
Body Normal	Positive	
Body Low	Negative	
Body Arched	Negative	
Tail Midline or Up	Positive	
Tail Tucked (around body, between legs)	Negative	
Tail Below Midline	Negative	
Sit	Positive	Cat is in an upright position, with the hind legs flexed and resting on the ground, while front legs are extended and straight
Lay	Positive	Cat's body is on the ground in a horizontal position, including on its side, back, abdomen, or curled in a circular formation. Legs may be extended or tucked under
Stand Still	Neutral	The cat holds an upright posture, with all four paws on the ground and legs extended, but is not in locomotion
Walk-Slink	Negative	Cat is locomoting with chest and abdomen close to the ground, legs not fully extended, may be pressed against walls or objects
Walk-Normal	Positive	Cat is locomoting with legs extended and relaxed body posture
Rub	Positive	Cat presses its body, or head, against object or surface
Jump	Neutral	The cat uses its legs and feet to vertically lift off of the ground

REPUTATION FORMATION IN DOMESTIC CATS

Purr	Positive	A “rumbling” sound which does not require the cat to open its mouth, often accompanied by other relaxed-type behaviors
Hiss	Negative	A sharp exhale of air
Meow	Positive	A staccatto annunciated vocalization, onomatopoeic in sound “merrr-oww” or “rah-oooww”
Yowl/Whine	Negative	A greater intensitiy meow often with the last vowel sound extended
Growl	Negative	A deep “groaning” sound often accompanied by stress-type behaviors
Paw at Door	Negative	The cat uses one or both front feet the manipulate the door
Pacing	Negative	Repetitive locomotion in a fixed pattern, such as back and forth along the same route. Can include walking, trotting, and running. Must be performed at least two times in succession.
Tail Wave	Positive	A slow and gentle wave of the tail from side to side
Tail Swish	Neutral	A violent swish of the tail; more rapid than tail wave
Tail Slap	Negative	Cat quickly strikes its tail on the ground
Running	Neutral	Forward locomotion at a rapid gait, faster than walking
Fur-plucking	Negative	Cat excessively grooms a specific area of its body. Can include tail or paw-sucking actions
Avoid	Negative	Cat moves, or changes direction while moving, in order to keep away from experimenter
Behind Experimenter	Neutral	The cat is behind the experimenter’s body
Rub Experimenter	Positive	Cat presses its body, or head, against the experimenter
Lick Experimenter	Positive	Cat uses tongue in repetition on the experimenter
Climb on Experimenter’s lap	Positive	Cat locomotes onto the experimenter’s crossed legs
Bite Experimenter	Negative	Cat closes its mouth and teeth around experimenter, may be seen when the cat is behaving negatively (as in attack) or positively (as in “love bites”)
Within square marker of Experimenter	Positive	At least one paw has crossed or is on the line of the square tape around the experimenter.
Eye contact with Experimenter		Cat is looking up in the direction of the experimenter’s eyes
Scratch Experimenter	Negative	Cat uses paw and claws in a swiping motion
Paw Experimenter	Positive	Cat uses paw(s) to touch experimenter, without the use of claws
Flee from E	Negative	Cat runs away from experimenter
Freeze	Negative	Cat suddenly becomes immobile with body tensed
Hiding	Negative	Cat occupies a location away from the experimenter
Grooming	Positive	Cat uses tongue in repetition on itself
Drink Water	Positive	Cat drinks water from the green water dish
Interact with litter pan	Neutral	Cat steps into, rolls in, or utilizes the litter pan
Out of camera sight	Neutral	Cat is not in view of the camera