Running head: Puppies use human social cues

When do dogs (*Canis lupus familiaris*) start to understand human pointing? The role of ontogeny in the development of inter-species communication.

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A decade of research indicates that dogs (*Canis lupus familiaris*) are sensitive to a variety of human social cues, including pointing with the hand and arm. Previous studies conducted with puppies as young as six weeks old, have reported that they are able to follow a pointing gesture, even when they have had little human contact. These results have led some experimenters to the conclusion that ontogeny does not play a role in dogs' ability to understand human cues. We tested puppies aged from 9 to 24 weeks to investigate the age at which this ability appears in human-home living dogs. The results of this study show little evidence of an ability to follow human points in puppies younger than 21 weeks.

Key words: *Canis*, dogs, human gestures, momentary proximal point, puppies, social cognition

Numerous recent studies show that domestic dogs are able to follow human points to locate hidden food or other desired objects (Miklósi et al. 1998; Hare & Tomasello 1999; Soproni, et al., 2001; Soproni, et al., 2002; Udell, Giglio & Wynne, 2008; Udell, Dorey & Wynne, 2008). This ability has been tested with the object choice task in which containers are placed an equal distance apart from an experimenter located between them. Once the baiting is complete the dog is brought in front of the experimenter who then points to the container that contains the accessible food. The dog is then released to make its choice. The pointing gesture shown to the dog can be altered both in distance from the finger tip to the container and in the duration of the point display. Several studies have concluded that dogs do extremely well in understanding a variety of human social cues (see Miklosi & Soproni 2006 and Udell & Wynne 2008 for reviews).

To date three studies have investigated domestic dog puppies' ability to follow human points. Hare et al. (2002) tested two groups of puppies (hand-reared and kennel-reared) that varied in age from 9 - 24 weeks old on their ability to understand a cross lateral proximal point with eye gaze, and eye gaze alone. In this study a cross lateral point was conducted by the experimenter laying on his belly and pointing with the index finger of the hand opposite to the baited container. The pointed finger reached within 10 cm of the container and the experimenter's head was also turned in the direction of the baited container. In another condition, the experimenter's head and eye gaze were directed towards the baited container and no hand point was presented. Hare et al. (2002) found no significant difference between the kennel-reared and hand-reared groups, or between the age groups for either cue. Both groups were able to follow both cues at above chance levels to find the food, with no evidence of learning across trials. Hare et al. (2002)

concluded that dogs must have obtained these skills through the phylogenetic process of domestication and not through human exposure during their lifetimes. This study employed a form of human point that is unique in the literature. To our knowledge only one other study (Hare et al., 2005) has performed a point in which the experimenter was lying on the ground. Lying on the ground might have made the experimenter more interesting and enticed the puppy to approach him (Dodman & Linder 2007). Furthermore, Hare et al. (2002) left the point in position until the puppy had made its choice. With this combination of experimenter posture and point type, and without control trials in which no point was given, it is impossible to rule out the possibility that the puppies were approaching the enticing person and then the hand which then led them to within 10 cm of the baited container.

Riedel et al. (2008) wanted to see if puppies could use human pointing gestures to find food before the peak socialization period of puppies to humans which occurs around seven weeks of age (Freedman, 1961). In experiment 1 Riedel et al. tested four age groups of puppies (6 weeks, 8 weeks, 16 weeks, and 24 weeks). All the puppies were reared by their mothers until 8 - 9 weeks of age at which time they were adopted into human households as pets. Each puppy was tested on its ability to follow two types of human point. The first was a dynamic cross point, where "cross" meant that the arm moved across the body toward the object and "dynamic" meant that the puppy observed the movement of the pointing arm and the resulting point stayed in position until the puppy had made its choice. The second was a dynamic cross move point in which the arm moved across the body toward the target object into a pointing position, returned back to the midline and then into the pointing position four times. On the fourth occasion

the index finger remained in the pointing position until the puppy made its choice. For both points the finger tip was 23 cm from the cup.

In addition to the pointing cues, Riedel et al. (2008) used a marker condition in which a marker was placed on the cup containing the hidden food, and a control condition where the experimenter remained in a neutral position with her head down while the puppy made its choice. For all conditions the researchers found that the puppies were significantly more successful on the experimental trials than in the control condition and this effect was not dependent on age. They also found that there was no evidence for learning within experimental sessions. Thus from these results they concluded that there is "strong evidence that human exposure has no major effect on dogs' ability to use human-given communicative cues and that this skill therefore represents a special adaptation in dogs that is present from an early age" (Riedel et al. 2008, p.10).

Wynne, Udell and Lord (2008) reanalyzed Riedel et al.'s (2008) data, pointing out that the initial ANOVA conducted by Riedel et al. (2008) included the control trials on which no improvement with age would be expected. When the control trials were removed so that only experimental trials were included in the analysis, Wynne et al. (2008) found that the older dogs were more accurate on human-guided choice tasks than the 6 week old puppies. They also found significantly better performance of 6 week old puppies in the second half of experimental trials compared to the first half, indicating a learning effect. Taken together these results suggest that experience plays an important role in performance on these types of tasks.

Gàcsi et al. (2009) used the object choice task to test puppies between the ages of 2 and 14 months and also adult dogs. They used a momentary distal point to test puppies'

and adult dogs' ability to follow human points to obtain food. Each subject received 20 trials and some of the subjects were retested weeks or months after the original study to see whether their performance improved over time. Gàcsi et al. (2009) reported no significant difference in the dogs' performance across ages. They also found no significant effects of learning between the first and second 10 trials and between the subjects' performance on the first and second testing periods. From these results they concluded that dogs' ability to understand the human pointing gesture is not affected by environmental stimuli after the age of 2-4 months.

Gasci et al. (2009) did not run control trials in which no point was given to test for other variables that could be controlling the behavior. Thus, the possibility remains open that their subjects detected either the smell of the food or other unintended cues from the experimenter. Furthermore, their analysis included wide and overlapping age categories (2-4 months, 4-6 months, etc.), thereby reducing the power of the analysis.

Although several prior studies have been carried out on this question, we felt that none was definitive given the above methodological concerns and thus the purpose of the present study was to investigate, first, if young puppies can follow human points and, if not, at what age they attain adult levels of performance on this task. In so doing we used a standard momentary proximal point, included control trials to test for unintended cues, and analyzed the results in discrete non-overlapping age categories.

METHOD

Subjects

Thirty-three puppies of various breeds participated in this study (see table 1 for breeds and ages). All the puppies were living in human homes as pets at the time of

testing and were volunteered by their owners for participation in the study. The puppies ranged in age from 9 - 24 weeks of age and consisted of 16 males and 17 females. For analysis the puppies were divided into four age groups of three weeks each: 9 - 12 weeks (10 individuals); 13 - 16 weeks (six individuals); 17 - 20 weeks (eight individuals); and 21 - 24 weeks (nine individuals).

Materials and Procedure

During all conditions the puppies were tested in a quiet room in their homes. Two opaque plastic (532 ml) SOLO™ cups were arranged so that one cup was placed inside the other and food (identical to the reward) was located in the space between the two cups. The food placed between the two cups functioned to equalize the odor given off by the hidden food item.

Puppies were run before their feedings either in the morning after they had woken up and were active, or after their afternoon naps. Dry puppy food, hotdogs, or Snausages™ was used to reinforce correct responses depending on what served as the greatest motivator for each puppy.

Location of the baited cup was randomized subject to the constraint that neither side was baited more than twice in a row. For each trial, in both the testing and control conditions, the experimenter noted whether the puppy selected the correct or incorrect cup and the location of the chosen cup from the puppy's vantage point (left or right). A correct choice was defined as touching or coming within 10 cm of the baited cup within three minutes.

Pretraining

Pretraining was conducted to demonstrate to the puppy that a cup may contain food and that the selection of the correct cup will be reinforced. Once the experimenter got the puppy's attention, (by calling the puppy's name or "puppy"), she held up a piece of food and placed it in one of the cups. The puppy was then allowed to approach the cups and choose one. If the baited cup was approached first the puppy was allowed to have the piece of food and was praised verbally. If the incorrect cup was chosen, the experimenter removed the food from the correct cup, showed it to the puppy and did not let the puppy consume the food. This procedure was repeated twice per side cup, totaling four trials. Pretraining trials were also used to test for and maintain motivation if a puppy made three incorrect trials in succession.

Testing

After successfully completing the four pretraining trials, the puppy immediately started testing trials. The puppy was prevented from viewing the baiting process by using a barrier within the owners' home (e.g. a couch or counter). The experimenter then "sham baited" the cups by placing a piece of food in each of them, but removed the piece of food from the incorrect cup before commencement of the trial. The purpose of this was to equalize the noise and odor to each cup during baiting.

Once the cups were in position, the assistant, either standing or sitting, gently restrained the puppy at a distance of 1.5 m from the cups (Figure 1). The experimenter sat on the floor with her legs crossed, 0.5 m back from the midline point between the two sham baited cups.

---Insert Figure 1 About Here---

Once the experimenter obtained the puppy's attention, (by calling the puppy's name or "puppy") she gave a momentary proximal point, which consisted of the extension of the ipsilateral arm toward the target container with the tip of her finger ending 10 cm from the cup. The experimenter's hand and arm remained in the pointing position for 1 s before returning to a neutral position. Once the experimenter was in a neutral position the puppy was released. If the puppy chose correctly it was permitted to eat the food hidden in the cup. If, however, the subject picked the incorrect cup, it was immediately escorted back to the starting position. Ten experimental trials were presented to each puppy. If any individual made three incorrect responses in a row, two pretraining trials were conducted (one on each side) to ensure that the puppy was still food motivated. During this study none of the puppies failed a test of motivation.

Control

Control trials were given after every two experimental trials. In these trials, a cup was predetermined at random as the correct choice. The experimenter obtained the puppy's attention as before and then looked straight ahead and gave no cue. As with the experimental trials, if the puppy chose the correct cup, it received the food reward. However, if the puppy chose the incorrect cup it was escorted back to the starting position without consuming the reward.

Statistical analysis

A one-way ANOVA was used to determine if there were any significant differences in performance between the age groups tested. If significant main effects were found, Bonneferoni corrected two-tailed *t*-tests were used to determine the ages between which significant differences occurred.

One-tailed single-sample t-tests were applied to compare the results of each age group against chance (50%) for both experimental and control trials.

Performance of individual subjects was assessed with a binomial test. To test for within-task learning, we compared the results of the first and second five trials using a paired t-test for each age group.

An alpha level of 0.05 was adopted throughout the statistical analyses.

RESULTS

The performance of puppies on the object choice task, requiring the use of a momentary proximal point, improved as a function of age. The number of individual subjects attaining eight or more out of 10 trials correct (binomial p = 0.05) increased from zero in the two youngest age groups, to two (of eight) in the 17-20 weeks group, and reached six of the nine subjects in the 21-24 weeks group.

The ANOVA found differences between the age groups in their mean rates of selecting the pointed-to container ($F_{3, 29} = 6.27$, $P = 0.002$). Corrected two-tailed t-tests identified that puppies in the 21 - 24 week age group were significantly more successful in following the point than puppies between 9 and 12 weeks of age ($t_{17} = 4.21$, $P = 0.03$) (Figure 2). Two-tailed t-tests comparing other groups uncovered no significant differences (largest $t_{16} = 1.95$, $P = 0.06$). One-tailed single-sample t-tests revealed that the puppies in the 21-24 week ($t_8 = 6.82$ p < 0.05) and 17- 20 week age groups ($t_7 = 2.22$ p < 0.05) performed significantly above chance. The other two age groups were not found to be significantly above chance (9-12 weeks $t_9 = -0.40$ p > 0.05; 13-16 weeks $t_5 = 0.25$ p > 0.05).

Paired T-tests were used to compare the first and last halves of sessions in each age group to test whether the subjects were learning across trials. None of the tests were significant (largest $t_7 = 1.83$, P = 0.10).

For the control trials the performance for each age group was not significantly better than chance (largest $t_5 = -1.34$ p > 0.05).

---Insert Figure 2 About Here---

DISCUSSION

The results of this experiment indicate that puppies improve at following momentary proximal points to find hidden food as they get older. The number of individual subjects attaining binomially significant results increased from zero in the two youngest age groups, to two out of eight in the 17-20 weeks group and six out the nine subjects in the 21-24 weeks group.

These findings are consistent with those of Riedel et al. (2008) as reanalyzed by Wynne et al. (2008). However, they are not consistent with the claims of Gàcsi et al. (2009), Hare et al. (2005), and Riedel et al. (2008) that the ability of dogs to follow points is not dependent on ontogenetic experience.

We believe that differences in methodology and analysis may account for the variation in results found in the different studies. As mentioned above, Hare et al. (2002) performed the cue while the experimenter was lying on the ground and left the point in position only 10-15 cm from the cup until the puppy made its choice. Thus the subject may have approached the experimenter's hand and as a result come close enough to a cup for it to be counted as a choice (10 cm from the cup). Such behavior by puppies was reported by Riedel et al. (2008). Although Hare et al. (2002) did run a gaze only

condition in which no point was given, this was not an adequate control to test for the possible unintentional cueing that that the puppies might have picked up on during testing. Furthermore, the results of the gaze only trials could have been due to an order effect and not on the puppies' initial ability to follow the gaze. Because Hare et al. (2002) gave all the puppies the gaze plus point cue followed by the gazing cue alone, there is no way to tell if the puppies gained information from the first point cue to perform above chance when tested with the gaze only cue.

Gàcsi et al. (2009) reported that if the subject did not leave the starting position within 3s, the point was repeated. By repeating the point, they added motion which could be considered a dynamic point (Miklósi & Soproni, 2006), as well as an additional presentation of the stimulus conditions. Since these results are not reported individually it is impossible to know the extent to which these different points had an effect on the outcomes observed.

Like Hare et al. (2002), Gàcsi et al. (2009) also failed to run controls for the smell of the food and other unintended body movements that could have cued the puppies to choose the correct cup. In past experiments, investigators have controlled for smell by placing one cup over another cup that contains the food reward (Miklosi et al., 1998; Udell, Giglio & Wynne, 2008). They have also conducted control trials identical to test trials, except that no cues are given (Hare and Tomasello, 1999; Arnetta, Hare & Tomasello, 2000; Bräuer et al., 2006; Udell, Giglio & Wynne, 2008). Gàcsi et al. (2009) rubbed the food over both cups to control for the smell and placed a piece of food in one of the cups. While this might have been enough to control for the smell, without control trials it is impossible to be certain. Certainly, the abilities of dogs to detect and

discriminate odors at low concentrations and under noisy conditions are very well established (Oxley & Waggoner, 2009)

Unlike Gàcsi et al. (2009) and Hare et al. (2002), control conditions were included in the present study to ensure the subjects were not using other cues or smell to locate the hidden food. We also utilized a momentary point, so that the experimenter returned to a neutral midline position before the puppy was released to make a choice. This type of point, unlike that used in Hare et al. (2002), controlled for the possibility that the puppies could be approaching the extended hand instead of the target, and thereby unintentionally meeting the criterion for a correct choice.

It could be argued that because we used a point that was not present when the puppies made their choice, our results are due to an improvement in the dogs' short term memory rather than an improvement in following the human point as such. However, before we began testing, we conducted pre-training trials in which each puppy was shown a piece of food being placed in the cup and was then released to collect the food. The fact that all pups tested in the experiment proper were successful on these pre-training trials implies that they all had adequate memory to succeed on the task.

The way Hare et al. (2002), Reidel et al. (2008) and Gàcsi et al. (2009) analyzed their data may also account for the variations in the results. All three studies reported that their statistical tests provided no grounds to reject the null hypothesis of no difference in performance between the age groups. Null hypothesis testing is not designed to test the hypothesis of no change in a variable. A failure to reject the null hypothesis is not proof that the null hypothesis is true.

Gàcsi et al. (2009) analyzed their data by dividing the puppies into six groups, but each group overlapped with the one before (i.e., 2-4, 4-6, 6-8 months, etc.). Overlapping age groups in this way leads to double counting of the data from most puppies and would have reduced the power of the analysis looking for differences across age groups. They also did not report what happened to trials in which the subject did not choose a cup. If these trials were repeated, as was done with subjects that did not leave the starting point within 3s, then Gàcsi et al. (2009) may have increased the likelihood that the subject would get the trial correct and thereby reduced possible differences in performance between the age groups.

The age groups used by Gàcsi et al. (2009) were also broader that than those in the current study and in Hare et al. (2002). The results of the current study may suggest that narrowly defined age groups are more effective at detecting developmental change.

In species other than dogs, ontogeny has been found to play a critical role in the development of the ability to follow human points. Okamoto-Barth et al. (2008) investigated the development of infant chimpanzees' skill in understanding a variety of human gestures. Three chimpanzees were tested once a week from the age of 8 months to 3 years old on a variety of gestures in the object choice paradigm. For the two pointing gestures deployed (close - 5cm, and distant - 20cm), Okamoto-Barth et al. (2008) concluded that all the subjects improved with age and experience. It should be noted, however, that because the investigators used the same subjects throughout the study it is hard to differentiate learning within the study (some subjects received up to 168 trials on one point type) with the effects of age.

304 Human infants have also been found to improve with age on understanding adult
305 points. Infants begin to follow an adult's point to objects that are close to the finger (50
306 cm) after 9 months of age (Murphy & Messer, 1977; Lempers, 1979). For more distant
307 points it takes infants 12 months before they will follow them to a target object (Lempers,
308 1979). Furthermore, human babies do not follow points to objects placed behind them
309 until they are well into their second year of life (e.g., Butterworth, 2001; Butterworth &
310 Grover, 1988, for reviews).
311 Behne, Carpenter and Tomasello (2005) conducted a study with infants between
312 14 and 24 months and Lakatos et al. (in press) report a study with 2 and 3 year old
313 children using an object choice task. Both studies found that the subjects improved with
314 age on a variety of point types.
315 Since interpretation of other peoples' actions is said to be one of the most
316 survival-critical tasks facing human infants and young children (e.g. Woodward &
317 Guajardo, 2002), one could see how humans might have acquired these abilities through
318 phylogeny. However, abundant evidence indicates that ontogeny plays a crucial role in
319 young humans' development of the ability to follow adults' points. Given that
320 developmental experience is so important when the communication is taking place within
321 one species, it seems surprising that investigators discount the role of ontogeny in dogs'
322 ability to follow human points (Hare and Tomasello, 1999; Hare et al., 2002; Riedel et al.
323 2008).
324 Different environmental stimuli (presence and absence of humans, con-specifics,
325 noises, etc.) during the critical period have been found to impact the social development
326 of canines (Scott and Fuller, 1965; Coppinger and Coppinger, 2001). Thus, future

research should investigate how much and what kinds of social interactions are needed before a puppy can use human cues to find hidden food. One possibility would be to have puppies in future studies raised under the control of the experimenters so that different groups could receive different amounts of different kinds of human interaction. Only studies of this type can convincingly demonstrate how much of what kinds of experience are necessary for dogs to acquire the ability to understand human gestures.

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403

404 FIGURE LEGENDS

405

406 *Figure 1:*

407 Sketch of testing layout.

408

409 *Figure 2:*

410 Bars show group average percentages correct. Error bars show standard errors of means.

411 Dashed line shows chance level (5/10). Data points indicate individual performance.

412 Number next to the data points show the number of individuals of the same age that have

413 the same score.

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417 Figure 1

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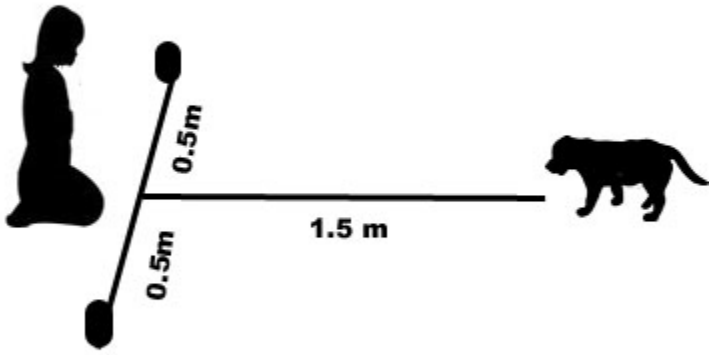

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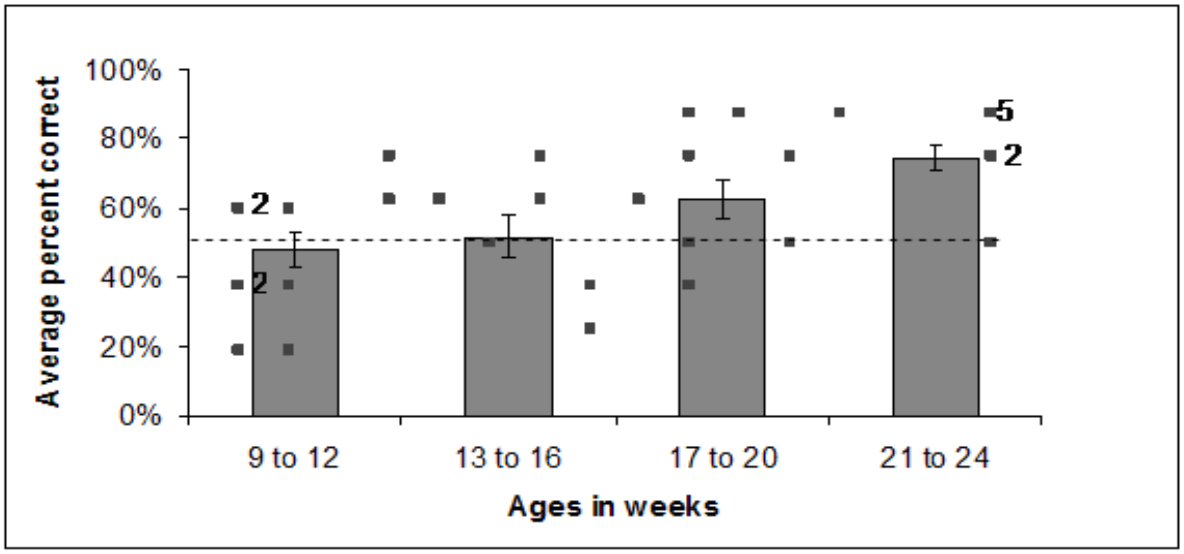
421 Figure 2



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423 Table 1: Name, breed, age and total correct responses (out of 10) for all subjects.

Subject's name	Breed type	Age	Total correct responses (out of 10)
Group 1			
Red Collar	German Shepherd	9 weeks	6
Puppy	German Shepherd	9 weeks	2
Memphis	German Shepherd	9 weeks	4
Molly	German Shepherd	9 weeks	4
Troy	German Shepherd	9 weeks	6
Tibel	German Shepherd	10 weeks	6
Myrtle	Australian Shepherd	10 weeks	3
Little Brown	Australian Shepherd	10 weeks	4
Leila	Mongrel	12 weeks	7
Blacken tan	Australian Shepherd	12 weeks	6
Group 2			
Gracie	Bull Mastiff	13 weeks	6
Jack	Havanese	14 weeks	5
Seeker	German Short Haired Pointer	15 weeks	6
Millie	German Short Haired Pointer	15 weeks	7
Arabella	German Shepherd	16 weeks	4
Astro	Airedale	16 weeks	3
Group 3			
Cami	German Short Haired Pointer	17 weeks	6

Tonka	Mongrel	18 weeks	4
Ada	Dachshund	18 weeks	8
Axel	Dachshund	18 weeks	7
Bren	Dachshund	18 weeks	5
Fiona	Newfoundland	19 weeks	8
Wednesday	Airedale	20 weeks	5
B.J.	Jack Russell Terrier mix	20 weeks	7
Group 4			
Roco	Boarder Collie	21 weeks	8
Max	Doberman Pincher	24 weeks	7
Casey	Brittany	24 weeks	5
Tucker	Brittany	24 weeks	8
Daisy	Doberman Pincher	24 weeks	8
Buttons	Australian Shepherd	24 weeks	8
Bridget	German Shepherd	24 weeks	8
Bruno	German Shepherd	24 weeks	8
Loci	Border Collie	24 weeks	7

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