More to the Point:

Dogs (*Canis familiaris*) interpret pointing as a command that conveys information

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Abstract

Dogs have a remarkable capacity to robustly and flexibly follow human pointing However, it remains unclear whether dogs interpret pointing as imperative, commanding them to go toward a certain location, or as informative, providing them with information about a certain location. In Study 1, we investigate the extent to which dogs interpret pointing as a command by using deceptive pointing and varying whether or not the pointer remains in the room. While there was no difference in the frequency at which dogs followed the deceptive pointing between conditions, dogs displayed higher latency times when the pointer remained in the room. These results indicate that dogs interpret pointing as some sort of imperative, but not as a strong command. In Study 2, we investigate the extent to which dogs interpret pointing as information by using third party deceptive and accurate pointing. Dogs follow deceptive pointing, even when conveyed to a third party, indicating that dogs can use pointing as information. Taken together, Studies 1 and 2 indicate that dogs interpret pointing as a weak command that conveys information.

Introduction

People have long considered dogs to be their best friends, and with good reason. We enjoy playing with and getting to know our dogs. We often believe that we understand what our dogs are thinking and feeling, and we believe that they can, at some level, understand us. Indeed, dogs are surprisingly responsive to various forms of human communication. Dogs follow gazing, head turning, nodding, and bowing in order to determine the location of hidden food (Hare et al., 1998; Hare & Tomasello, 1999; Reidel el al., 2006; Sopróni et al., 2001). The social cue that dogs are most sensitive to is pointing.

When a human points to the location of hidden food, dogs consistently follow the point (Hare et al., 1998; Hare et al., 1999; Miklósi et al., 1998). Dogs' ability to follow pointing easily surpasses that of non-human primates (Brauer et al., 2006; Hare et al., 2005; Kirchhoefer et al., 2012). Chimpanzees follow pointing slightly above chance when it is continuous—present up until the chimpanzees make a choice—and proximate—when the pointing finger is within 20cm on of the indicated object (Brauer et al., 2006; Povinelli et al 1997). Still, chimpanzees only follow proximate continuous pointing 60% of the time (Brauer et al., 2006). Conversely, dogs follow the same pointing at a frequency of more than 90% (Brauer et al.).

Dogs also demonstrate a degree of flexibility in following various types of pointing (Soproni et al., 2002; McKinley & Sambrook, 2000; Kaminski et al., 2012). Dogs follow pointing independent of the location and movement of the pointer. When the pointer stands behind a non-baited cup and points to the baited cup, dogs will approach the baited cup (Hare et al., 1998), suggesting that dogs follow the direction of the point

instead of approaching the location that is made more salient by the pointer's presence. Dogs also follow pointing when they see humans walk away from a baited cup while pointing toward it (McKinley & Sambrook, 2000). Dogs follow pointing whenever a hand or foot extends from the outline of the body frame (Soproni et al., 2002; Lakatos et al., 2009).

Studies comparing wolves and dogs and investigating the early ontogeny of pointing suggest that dog's ability to follow pointing is unique to dogs. While wolves can follow certain kinds of pointing, their proclivities and capabilities of following pointing are much more limited than dogs' (Hare et al., 2002; Reidel et al., 2008; Virányi et al., 2008; Gasci et al., 2009). Virányi et al. (2008) found that whereas dog puppies follow proximate pointing at 4 months, wolf puppies do not do so until they are 11 months of age. As adults, wolves can follow distal pointing—wherein the pointing finger is more than 70cm away from the indicated object—but only after thorough training (Hare et al., 2002; Virányi et al., 2008). In contrast, dogs follow distal pointing, and a variety of non-standard types of pointing, spontaneously. Some scholars argue that dogs display this flexibility in following pointing as a result of the exposure to pointing and other social cues in a pet dog's environment (Udell et al., 2008; Elgier et al., 2008). However, Reidel et al. (2008) found that dogs as young as 6 weeks consistently follow proximal pointing. At 6 weeks, puppies have not yet been separated from their mothers and so did not have extensive exposure to human social cues. Additionally, dogs followed pointing to the same degree at 6, 8, 16, and 24 weeks of age, suggesting that dogs are not learning how to follow pointing as they become more socialized. Taken together, these pieces of

evidence suggest that dogs follow pointing not because of a capacity within all canids, but rather due to a particular proclivity that arises ontogenetically within dogs.

The uniquely robust and flexible response to pointing present in dogs indicates that dogs developed this proclivity to follow pointing through the process of domestication. The process of domestication began between 15,000 and 36,000 years ago (Vila et al., 1997; Gernopre, 2009). Throughout the domestication process, dogs diverged from their common ancestors with wolves. One aspect of the domestication process was the increased ability of dogs to follow pointing (Miklósi et al., 2003; Hare et al., 2005). This ability could have arisen as a result of two basic types of selection. First, dogs may have acquired the proclivity to follow pointing incidentally, as a by-product of humans selecting for tamer dogs (Hare et al., 2002; Hare & Tomasello, 2005; Kaminski et al., 2012; Kaminski & Nitzschner, 2013). Under this theory, selection for tameness alone facilitates a variety of genetic, morphological, and behavioral changes (Trut et al., 2004; Hare et al., 2005). In support of this theory, after selecting for only tameness, silver foxes spontaneously developed the capacity to follow pointing after 6 generations of selection (Hare et al., 2005). An alternative to the by-product hypothesis is the adaptation hypothesis, in which humans actively selected for dogs that were most responsive to certain human social cues (Miklósi et al., 2003; Kaminski & Nitzschner, 2013). Under the by-product hypothesis, dogs should be flexible in their processing of human social cues. Conversely, dogs may or may not be flexible in their processing of human social cues under the adaptation hypothesis because dogs may have been selected for responses to more rigid cues.

However the proclivity to follow pointing arose in dogs, this tendency is undoubtedly strong, so much so that dogs follow pointing even when it is deceptive (Szetei et al., 2003; Petter et al., 2009; Kundey et al., 2010). For example, dogs override olfactory information to follow pointing to an un-baited cup above chance. When dogs are able to see where the treat is placed and can smell both locations, dogs will still follow pointing at chance (Szetei et al., 2003; Kundey et al., 2010). When not provided with visual information, dogs follow deceptive pointing above chance for more than 100 trials (Petter et al., 2009).

Thus, while much evidence demonstrates that dogs follow pointing robustly and flexibly, even when the pointing is deceptive, it remains unclear how dogs actually interpret pointing. There are two general ways that dogs could interpret pointing—as *imperative* or as *informative*. Tauzin et al. (2015) demonstrate that dogs interpret pointing as referring to a location or direction as opposed to an object. Given this evidence, if dogs interpret pointing as an imperative, they would interpret pointing as commanding them to go toward a certain location or in a certain direction ("Go over there"). Conversely, if dogs interpret pointing as information, dogs would interpret pointing as conveying something about a certain location or direction ("There's something over there").

Distinguishing between whether dogs interpret pointing as imperative or informative would help to clarify how dogs interpret communication with humans more generally. If dogs interpret pointing as informative, that result would suggest that dogs can understand human communication as conveying information and therefore that dogs have the capacity to understand something as information. Conversely, if dogs interpret pointing solely as a command, that result may indicate that dogs interpret all kinds of

communication with humans in an imperative framework (Kaminski et al., 2012). Additionally, understanding how dogs interpret pointing may impact how future studies involving the social cue of pointing are designed. If dogs interpret pointing as a command as opposed to information, that may affect the conclusions of experiments whose results depend upon dogs following pointing.

To begin to answer the question of whether dogs interpret pointing as imperative or informative, Scheider et al. (2013) examined whether or not dogs interpret pointing as a strong command by utilizing deceptive pointing. Deceptive pointing puts a dog's proclivity to follow pointing in tension with a dog's desire to obtain treats. The circumstances under which a dog continues to follow pointing despite not obtaining treats could elucidate how dogs interpret pointing in general. Scheider et al. (2013) defined a strong command as an imperative that commands a dog to carry out or refrain from a certain action, like "sit" or "don't eat it." If dogs interpret pointing as a strong command, the dogs would interpret pointing as commanding them to move toward a certain location. If dogs treat pointing differently than strong commands that result would indicate that dogs *interpret* pointing differently, either as a different sort of command or not as a command at all.

One of Scheider et al.'s (2013) experiments examined the frequency at which dogs followed deceptive pointing after the pointer either left or remained in the room. Previous work has shown that dogs follow the command to refrain from eating food much less frequently and for shorter durations when the person who commanded the dog leaves the room (Call et al., 2003; Schwab & Huber, 2006). Thus, if dogs interpret pointing like they interpret the strong command "don't eat it," dogs should follow

deceptive pointing less frequently when the pointer leaves the room. However, dogs followed pointing at the same frequency whether or not the pointer remained in the room, providing evidence that dogs do not interpret pointing as a strong command.

In another experiment, Scheider et al. (2013) investigated whether or not the age of the pointer affected how frequently dogs followed pointing. If dogs interpret pointing as a strong command, they should follow pointing more frequently when an adult—who has more authority—points and less frequently when a child points. Scheider et al. (2013) directly compared the behavior of dogs to pointing and to the command "sit" when delivered by an adult or a child. While Scheider et al. (2013) found that dogs followed "sit" more frequently when delivered by an adult, they found no difference in dog behavior when adults and children directed them with pointing. Thus, Scheider et al. (2013) concluded that dogs do not interpret pointing the same way that dogs interpret a strong command like "sit."

Taken together, Scheider et al. (2013) found that dogs do not interpret pointing as a strong command. While Scheider et al. (2013) provides compelling evidence that dogs interpret pointing differently than they interpret commands like "sit" or "don't eat it," there are still a number of largely uninvestigated ways that dogs could interpret pointing. It is possible, for example, that dogs interpret pointing as a weaker imperative than a strong command, perhaps as more of a suggestion of where to go than a fixed command (Scheider et al., 2013). Alternatively, dogs could interpret pointing primarily as informational. We conducted two studies to further narrow down the possible ways in which dogs could be interpreting pointing.

In Study 1, we examined the extent to which there is evidence for dogs interpreting pointing as a command, either a strong command in which dogs are directed to go toward a certain location, a weak command in which the pointer suggests where the dog should go, or as not a command at all. Study 1 largely drew from a portion of Scheider et al.'s (2013) procedure, examining the extent to which dogs followed deceptive pointing when the pointer left or remained in the room and the amount of time dogs spent making their choices.

If dogs follow deceptive pointing more frequently when the pointer is present, that result would indicate that dogs interpret pointing as a strong command because dogs follow strong commands more frequently when the commander is present. Conversely, if the dogs follow pointing to the same extent in each condition, that result would suggest that the presence of the pointer is irrelevant to the dog's choice and therefore that dogs do not interpret pointing as a strong command. If, as we predict based on Scheider et al. (2013), dogs follow pointing equally across conditions, the latency time data may help to clarify whether dogs interpret pointing as a weaker imperative or as not a command at all. If dogs display a difference in latency times between conditions, that result would indicate that dogs interpret pointing as a type of command because the presence of the pointer plays a role in the dog's response to the point. If dogs display no latency time difference between conditions, that result would indicate that dogs do not interpret pointing as an imperative of any kind.

In Study 2, we examined the extent to which dogs interpret pointing as information. If dogs interpret pointing as information, they should utilize that information even when it is not addressed to them (Kaminski & Nitzschner, 2013). Expanding on a

procedure in Kaminski et al. (2012), Study 2 examined the extent to which dogs followed inaccurate (deceptive) and accurate pointing that was addressed to a third party. If dogs interpret pointing solely as a command, they should perform at chance because they are not being commanded to go anywhere when the pointing is not intended for them. If, however, dogs interpret pointing as information, they should be able to use that information and follow pointing above chance in both conditions.

Study 1: Direct Pointing

Method

Dog subjects. We tested 40 dogs of varying breeds. 23 additional dogs were tested but excluded due to failure to pass the warm-up trials (15) or two consecutive No Choices (8). All dogs were pets whose owners volunteered for participation by entering their dogs' information in an online database. Subjects were required to show no aggressive tendencies, be up to date on all their vaccinations, and be older than 6 months of age. We used $1cm^3$ cubes of Natural Balance beef sausage for all dogs except for those who were allergic to sausage and received alternate treats of the same size. Before participation, all dogs visited the center at least once before testing to become familiar with the center.

Testing Setup. Subjects were tested in the presence of two experimenters (NS and NF) and one owner. NS performed as the pointer and NF acted as the provider/preventer. Dogs were tested in a large room (*3.5m* x *3.15m*) at our center. A leash (approximately *2.5m* long) restricted subjects. During testing, the owner sat in a chair and held the subject's leash until cued to release the subject. The leash was clipped to a built-in hook in the wall. Two cups sat on plates 1m away from the dog. Both of the

cups had treats in their false bottoms so that dogs could not discriminate between the two cups based on olfaction. The cups were equidistant from the dog and were placed to the right and left of the dog respectively (Figure 1).

Design and procedure. All subjects participated in one warm-up phase followed by one testing phase. In the *warm-up phase*, subjects were able to approach the cups after seeing where the treat had been placed. The goal of this warm-up phase was to ensure that subjects were motivated to retrieve treats and were capable of approaching the cup under which they had seen the treat placed. In the *experimental phase*, subjects received eight pointing trials in which they witnessed ostensive proximal ipsilateral pointing to the un-baited cup. In the experimental trials, subjects had not seen where the treat had been placed. The placement of the treat was pseudorandom such that treats were never placed under the same cup more than twice in a row. Subjects were randomly placed in either the *present* or *absent* condition. In the present condition, the pointer remained in the room after pointing. In the absent condition, the pointer left the room after pointing. If subjects interpret pointing as a command, they should follow the deceptive pointing more frequently in the present condition than in the absent condition.

Warm-up trials. Four warm-up trials were conducted in which the pointer placed a treat under one of the two cups in view of the dog. During the course of the warm-up trials, the pointer never made eye contact with the dog. The pointer knelt down behind the cups and placed a trifold between himself and the dog in order to eliminate accidental cues. When the pointer placed the trifold down, the owner and the provider/preventer would close their eyes so that they were both blind to the placement of the treat. The pointer would then placed a treat under one of the two cups. Once the treat was placed,

the pointer removed the trifold and the provider/preventer opened and closed the door. In the present condition, the pointer remained in the room. In the absent condition, the pointer left the room when the provider/preventer opened the door. When the door closed, the owner released the subject and the owner and the provider/preventer opened their eyes. Once the dog had crossed a line 10 inches away from the cup, the provider/preventer lifted up the cup. If the cup contained the treat under it, the dog was allowed to eat the treat. If the cup did not contain the treat under it, the provider/preventer showed the dog that the treat was under the other cup but did not allow the dog to eat the treat. If the dog selected the non-baited cup on more than one trial, the dog was excluded from the study.

Experimental trials. If the dog passed the warm-up trials, the experiment proceeded to eight experimental trials that were modeled closely off the warm-up trials. Specifically, as in the warm-up trials, the pointer would place the trifold in front of himself at which point the owner and provider/preventer would close their eyes. However, unlike in the warm-up trials, the trifold was placed in front of the cups in the experimental trials so that the dog could no longer witness the hiding process. Instead of allowing the dog to see the hiding process, the pointer would hold up a treat above the trifold and make a clicking noise to get the dog's attention. Then he would hide the treat under on of the cups and remove the trifold.

Once the pointer removed the trifold, he would capture the dog's attention by looking directly at the dog and saying, "[Dog's name]! [Dog's name]!" Once the dog's attention was captured, the pointer said "[Dog's name]" while maintaining eye contact with the dog, and then the pointer shifted his gaze to the empty cup while he ipsilaterally

proximally pointed to that cup and said, “Look!” The pointer repeated this procedure so that he pointed to the cup three times. After he was done pointing, the pointer dropped his head and his hands and remained stationary. At this point, the provider/preventer opened and closed the door. In the present condition the pointer remained kneeling behind the cups. In the absent condition, the pointer left the room when the provider/preventer opened the door.

When the door closed, the owner released the dog, and the owner and the provider/preventer opened their eyes. The provider/preventer approached the cup that the dog had approached and provided the dog with the treat if the dog had chosen the baited cup or showed the dog where the treat was and prevented the dog from eating the treat if the dog chose the un-baited cup. If the dog did not approach one of the two cups within 30 seconds, the trial was considered to be a “No Choice.” The provider/preventer would show the dog where the treat was and proceed to the next trial. If there were two consecutive No Choices, the dog was disqualified from proceeding with the study.

If dogs interpret pointing as a strong command, dogs should follow the deceptive pointing more often in the present condition, just as dogs follow strong commands like “don’t eat it” or “lie down” more often when the commander remains in the room (Call et al., 2003; Huber and Schwab, 2006). Additionally, dogs should exhibit a difference in latency times depending on whether or not the pointer remains in the room. Either the presence of the pointer would facilitate a quicker approach to the indicated cup or the presence of the pointer could increase the latency to choice because the dog experiences a greater tension between the drive to obey the command and the drive to obtain the treat. If dogs interpret pointing as a command but not as a strong imperative, there should be no

difference in choices between the two conditions. However, there should be a difference in latency times due to the presence or absence of the pointer.

If dogs do not interpret pointing as information and not as a command of any kind, they should follow pointing at the same frequency across conditions. Information, whether it be good or bad information, is still information independent of where the provider of that information is. Thus if dogs interpret pointing solely as information and not as a command, they should follow deceptive pointing equally across trials as they are receiving the same information in both conditions. Additionally, there should be no difference in latency times between the conditions because the continued presence or absence of the information provider should do nothing to more or less effectively convey the information.

Coding and Analyses. Choice outcome and latency to choose were each fully coded by the author (NS) and an additional coder (LN) who was blind to hypothesis. Choice outcome was defined as whether or not the dog followed the pointing. Latency to choose was defined as the amount of time between owner release of the dog and the dog's head passing the line in front of the cup. Eight No Choice trials were excluded from choice outcome analysis. The No Choice trials were included in latency time analysis. The latency times for No Choice trials were input as 30 seconds. Reliability was high for each of the outcome variables (r = 87% for choice outcome, r = 90% for choice latency).

Statistical analyses were conducted using R statistical software (version 3.2.1, R Foundation for Statistical Computing, Vienna, Austria). Choice outcome was analyzed using generalized linear mixed models (GLMMs) with a binary response term (for choice

outcome: follow pointing = 1 and did not follow pointing = 0). Predictors of interest were condition (present or absent) and trial number. To control for repeated measures, subject identity was included as a random effect. All mixed models were run using R package 'lme4' (Bates, Maechler, & Bolker, 2012).

In mixed model analyses, we first examined a null model, which included only subject identity. We then compared the null models with full models that included all predictor variables and their interactions. Model comparisons were conducted with likelihood ratio tests.

Results

Dogs followed the deceptive pointing at the same level of frequency in both the present and the absent conditions. Across eight trials, dogs followed pointing 73.8% of the time in the present condition and 74.4% of the time in the absent condition. Our full model for choice outcome was no better at predicting choice outcome than our null model (*Ps* = .396). When the choice outcome data was aggregated across conditions, dogs followed pointing at a frequency of 74%, significantly above chance ($t = 8.46$, $df = 39$, $p < .001$) (Figure 2).

While dogs did not exhibit a difference in choice between trials, they did exhibit a difference in latency times. Across eight trials, dogs had an average latency time of 4.91 seconds in the present condition and 2.56 seconds in the absent condition. Our model for choice latency was predicted by condition (LRT: $\chi^2 = 8.155$, $P = .004$) and by trial (LRT: $\chi^2 = 7.940$, $P = .005$). No other factors or interactions were significant predictors (LRT: *Ps* > .270). For both conditions, the latency time increased over the course of the trials. However, the latency time increased to a much greater degree in the present condition

than in the absent condition (Figure 3).

Discussion

We found no difference in the extent to which dogs followed deceptive pointing in the present and absent conditions. This result replicates Scheider et al.'s (2013) claim that dogs do not interpret pointing as a strong command. If dogs had followed deceptive pointing more frequently in the present condition, that result would have indicated that the presence of the pointer increases the likelihood that dogs follow pointing. Since dogs follow commands like "don't eat this" more often when the commander is present, this would support the claim that dogs follow pointing as a strong command. However, dogs did not show this difference, indicating that the presence of the pointer did nothing to affect the choice behavior of the dogs. Thus the choice outcome data provided evidence against the claim that dogs interpret pointing as a strong command.

While the presence of the pointer did not have an effect on the choices that the dogs made, the presence of the pointer did have a significant effect on the time it took for dogs to make those choices. Dogs took a reliably longer time to choose a cup when the pointer remained in the room. The presence of the pointer would only be relevant to the dog if dogs interpret pointing as some kind of command. If dogs interpret pointing purely as information, the presence or absence of the one who provides that information should be irrelevant because the location of the owner would do nothing to facilitate conveying the information communicated through pointing. Thus, dogs would have displayed no latency time difference between conditions. If dogs have no interpretation of pointing and automatically respond to it, there would also be no reason for dogs to approach one of the cups after a longer period of time. Thus, the latency data from Study 1 provide evidence

that dogs interpret pointing as a "weak" command, or a suggestion to go toward a certain location.

Taken together, Study 1 provides evidence that dogs do not interpret pointing as a strong command but do interpret pointing as a different sort of weak command. However, it remains unclear whether dogs interpret pointing simply as a weak command or as a weak command that also conveys information. Study 2 was designed to discriminate between these two options by investigating the extent to which dogs followed pointing when it was addressed to a third party. If third party pointing influenced dogs' behavior, that result would indicate that dogs may interpret pointing as information.

Study 2: Third Party Pointing

Method

Dog subjects. We tested 40 dogs. 14 additional dogs were tested but excluded due to failure to pass the warm-up trials. All dogs were recruited from the same database described in Study 1. However, none of the dogs tested in Study 1 were tested in Study 2. We used $1cm^3$ cubes of Natural Balance beef sausage for all the dogs except for those that were allergic to sausage, which received alternate treats of the same size.

Testing setup. The setup for Study 2 was identical to that of Study 1 with two changes. First, the provider/preventer was a different person (MB). More significantly, an additional experimenter (AJ or AZ) was present in the room. This additional experimenter was in the room because the pointer addressed his point to this experimenter instead of to the dog. This experimenter sat near one of the corners of the room that was adjacent to the dog's corner. The side where this experimenter sat—either

to the left or to the right of the dog—varied between dogs so that there was an equal number of times that the experimenter was to the right and to the left of the dog.

Design and procedure. The method of Study 2 was identical to that of Study 1 with a few important exceptions. The additional experimenter was present for the duration of the experiment. In the warm-up trials, the additional experimenter would watch the pointer hide the treat and then drop her head when the trifold would move the trifold from in front of himself. The additional experimenter would look at the pointer's head and not at the cup so as not to cue the dog to one cup or the other through gaze. Just as in the warm-up trials for Study 1, the pointer did not make eye contact with any individual.

In the eight experimental trials, the pointer addressed his pointing to the additional experimenter and never made eye contact with the dog. The additional experimenter would have her eyes closed at the start of each trial. After the pointer had hidden the treat and removed the trifold, he would look at the additional experimenter and say "[Experimenter's Name]!" When the additional experimenter heard her name, she would look at the pointer. The pointer would then point at one of the cups—the baited cup in the accurate condition and the un-baited cup in the inaccurate condition—in a manner identical to that in Study 1 with the exception that it would all be addressed to the additional experimenter. Once the pointer had pointed three times, he and the additional experimenter would drop their heads simultaneously. From this point on, the trial proceeded exactly as detailed for the present condition of Study 1.

If dogs follow third party pointing above chance, that result would indicate that dogs interpret pointing as information. Information can be used by anyone, regardless of

whom the provider of the information is addressing. If dogs follow third party pointing at chance, that result would suggest that dogs do not interpret pointing as information. If there is nothing to glean from the interaction of one person addressing pointing toward another, then the dog would have no reason to approach one cup over the other.

Coding and Analyses. As in Study 1, choice outcome and choice latency were each fully coded by the author (NS) and an additional coder (LN) who was blind to hypothesis. The same coding criteria used in Study 1 were used in Study 2. One No Choice trial was also excluded from choice analysis. Reliability was high for each of the outcome variables (r = 95% for choice outcome, r = 90% for choice latency).

Statistical analyses were conducted in the same way as in Study 1. Choice latency was log transformed and analyzed using linear mixed models (LMMs), as the transformed response variable had a normal error distribution. For both choice outcome and choice latency, the present trials from Study 1 were compared to the inaccurate trials from Study 2 to determine if there was a significant difference between the data. These two conditions were compared because the only differences between them were 1) the presence of AJ/AZ and 2) the recipient of the pointing. The between-subject predictors of interest were again condition (inaccurate or accurate) and trial number.

Results

Dogs followed third party pointing significantly above chance when the pointing was inaccurate. Dogs also followed third party pointing when the pointing was accurate, but the pattern was not significantly above chance. Dogs followed pointing across the accurate and inaccurate conditions 65.2% of the time. Our model for choice outcome was predicted by condition (LRT: $\chi^2 = 5.042$, $P = .025$) and by trial number (LRT: $\chi^2 =$, $P =$

.032) within Study 2. No other factors or interactions were significant predictors (LRT: *Ps* > .324). The choice outcome data for the inaccurate condition demonstrated that dogs followed pointing at a frequency of 72%, significantly above chance ($t = 6.737$, $df = 19$, $p < .001$). The choice outcome data for the accurate condition demonstrated that dogs followed pointing but this trend did not reach significance ($t = 1.820$, $df = 19$, $p = .085$ (Figure 2).

Dogs exhibited the same average latency time across the accurate and inaccurate conditions. Our full model for choice latency was no better at predicting choice latency than our null models (*Ps* = .295). Thus we did not find any evidence that there was any difference between latency times in the accurate and inaccurate conditions.

Discussion

Overall, dogs followed third party pointing. Dogs followed inaccurate third party pointing significantly above chance. Dogs also followed accurate third party pointing, but not *significantly* above chance. These results support the hypothesis that dogs interpret pointing as information because the pointing influenced their choices even though it was not addressed to them.

While we anticipated that dogs might follow third party pointing above chance, we did not expect that dogs would follow inaccurate third party pointing more frequently than accurate third party pointing. The data from the inaccurate condition of Study 2 demonstrate that dogs can and do use the information gleaned from pointing to choose which cup they approach. It seems strange that dogs are able to use this information but follow pointing less when the indicated cup contains food and more when the indicated cup does not contain food. On the first trial, 70% of dogs in each condition followed

pointing, dismissing the possibility that dogs in the accurate condition happened to have a lower proclivity to follow pointing. It seems that for some reason, third party pointing took on a greater salience when it was inaccurate. It is possible that dogs experienced violations of expectation in the inaccurate condition when they saw that the indicated cup did not contain a treat. This might have heightened the salience of whatever information they could get. Since the only information they could obtain in the situation was pointing, they might have paid more attention to pointing. Conversely, in the accurate condition, the dogs would not have experienced a violation of expectation, so the dogs might experience less motivation to pay attention to the pointing.

A greater adherence to inaccurate pointing was surprising, but the choice pattern obtained for the accurate condition was similar to the results from a comparable condition conducted by Kaminski et al. (2012). Kaminski et al. (2012) found that dogs followed accurate third party pointing above chance, but dogs followed this pointing much less frequently than when they were addressed directly with pointing. Since Kaminski et al. (2012) found that dogs followed accurate pointing significantly more frequently when it was addressed to the dogs than when it was addressed to a third party, Kaminski et al. (2012) concluded that dogs interpret pointing as communication directed to the addressee and thus less relevant to other individuals.

While our accurate pointing data aligned with Kaminski et al.'s (2012), our inaccurate pointing results suggest that dogs may be able to use third party pointing to a greater degree than Kaminski et al. (2012) suggested. If dogs followed inaccurate third party pointing at chance, that would support the hypothesis that dogs interpret pointing solely as a command that is primarily relevant to the individual addressed. However,

dogs followed inaccurate third party pointing well above chance, indicating that dogs may interpret pointing as information. While Study 2 establishes that dogs can use information obtained from third party pointing, we needed to compare the choice behavior of dogs in the third party inaccurate condition of Study 2 to the choice behavior of dogs in the direct pointing present condition of Study 1 in order to determine the extent to which dogs interpret pointing as information.

Results – Comparing Study 1 and Study 2

We compared the behavior of dogs in the present condition of Study 1 to the behavior of dogs in the inaccurate condition of Study 2. Analyses were conducted between these conditions because the only differences between them were 1) that another experimenter was in the room and 2) that the pointer addressed his pointing to this additional experimenter. If dogs follow pointing just as frequently in the present condition of Study 1 and the inaccurate condition of Study 2, those results would indicate that dogs interpret pointing as information. If dogs followed pointing less frequently, though still above chance, in the inaccurate condition of Study 2 than in the accurate condition of Study 1, those results would indicate that dogs interpret pointing as information, but also as a command that is followed more closely when directly addressed.

We found no difference in the choices that the dogs made between deceptive pointing that was addressed to them in the present condition of Study 1 and deceptive pointing that was addressed to a third party in Study 2. These results indicate that dogs use pointing as information. Our model for choice outcome was predicted by trial number (LRT: $\chi^2 = 7.582$, $P < .001$) for the present condition of Study 1 and the inaccurate

condition of Study 2. No other factors or interactions were significant predictors ($P >$ .341)

We did find a difference in the latency times between the present condition in Study 1 and the third party inaccurate condition of Study 2. Dogs had increased latencies to choice in the direct pointing present condition as opposed to the third party pointing inaccurate condition. Our model for choice latency was predicted by trial number (LRT: $\chi^2 = 11.403$, $P < .001$) and marginally predicted condition (LRT: $\chi^2 = 3.823$, $P = .051$) for the present condition of Study 1 and for the inaccurate condition of Study 2. Thus, we found evidence that dogs follow deceptive pointing to a similar extent when it is directed toward them and when it is directed toward a third party.

General Discussion

Across two studies, we examined the extent to which dogs interpret pointing as imperative and informative. Study 1 found that dogs follow deceptive pointing above chance and with the same frequency whether or not the pointer remains in the room. This provides evidence against the claim that dogs interpret pointing as a strong command, replicating the findings of Scheider et al. (2013). While dogs do not interpret pointing as a strong command, our latency time data demonstrated that dogs take a longer time to follow deceptive pointing when the pointer is still present. If dogs interpret pointing as information or do not interpret pointing at all and simply respond to it automatically, there would be no reason for a difference in latency times that depend on the presence of the pointer. This difference in latency times indicates that dogs do interpret pointing as a type of a command. Taken together, Study 1 provides evidence that dogs interpret

pointing as a weak command: the presence of the pointer has an impact on the dog's behavior but not to the extent that it changes what the dog decides to do.

Whereas Study 1 directly investigated how dogs might interpret pointing as a command, Study 2 investigated how dogs might interpret pointing as information by employing third party pointing. Dogs followed inaccurate third party pointing to the same extent that dogs followed direct deceptive pointing in the present condition of Study 1. This result suggests that dogs interpret pointing as information because dogs followed inaccurate pointing to the same extent whether or not it was addressed to them. One requisite for interpreting pointing as information is the ability to use that information when it is presented to another individual (Kaminski et al., 2013). In Study 2, dogs demonstrated that they use information conveyed in third party pointing.

Taken together, our results from Study 1 and Study 2 suggest that dogs interpret pointing as a weak command that conveys information. The command aspect of dogs' interpretation of pointing serves to explain why dogs took a longer time to choose a cup while in the presence of the pointer. It also might help to explain why dogs followed accurate third party pointing in Study 2 less frequently than the inaccurate direct pointing in Study 1 and the accurate direct pointing in Kaminski et al. (2012). Dogs may have followed the accurate third party pointing less frequently because when the pointing was not addressed to the dog, the dog did not experience the command aspect of the pointing. Thus, the information conveyed by the pointing, though still accessible to the dogs (on the first trial, 70% of dogs followed third party pointing), was less salient.

However, the information dogs gain from pointing is not without constraints. Specifically, dogs seem to interpret pointing in an exclusively positive manner. That is,

dogs interpret pointing as indicating where on *should* go as opposed to indicating where one *should not* go. In the three conditions that involved deceptive pointing, dogs followed pointing over 72% of the time. If pointing conveyed information that could be manipulated in any way, dogs should be able to interpret pointing in this context as providing information that there are no treats in a certain location or that the dog should not go in the indicated direction. However, the data indicate that the dogs consistently go to the indicated cup, continuing to interpret the information from pointing as positive. This is consistent with Petter et al.'s (2008) results, which show that dogs require intensive training—more than 100 trials of pointing—to learn that a point toward one direction conveys that the dog should go in the opposite direction.

Some scholars have argued that dogs have no mental representation of pointing, interpreting pointing neither as a command nor as information but rather simply responding automatically to pointing (Elgier et al., 2008; Elgier et al., 2012; Petter et al., 2009). The difference in latency times between the present and absent conditions of Study 1 provide evidence that dogs do in fact interpret pointing as a command (in part), and therefore not simply as an automatic association. In Study 2, dogs do not follow pointing to the same degree in the accurate and inaccurate conditions. While it may seem counterintuitive that dogs would follow third party pointing more consistently when it is inaccurate, the difference between the two conditions indicates that dogs respond to pointing differently depending on the circumstances. Combined with Kaminski et al.'s (2012) findings that varying the degree and recipient of ostensive cueing changes the extent to which dogs follow pointing, these results indicate that dogs do not merely associate pointing on a low-level. Rather, dogs respond differentially to different kinds of

pointing under different circumstances because dogs interpret pointing beyond an automatic response.

While Studies 1 and 2 contributed to the growing literature on dogs' interpretation of human pointing, the conclusions of these studies are limited in a few ways. The pointing in Studies 1 and 2 was always proximate, involved eye contact, saying the name of the addressee, and saying "Look!" and was repeated three times. Our conclusions may not hold for other types of pointing that varies these aspects of the social cue. For instance, repeating the pointing in this experimental setting may have amplified the command aspect of pointing. Additionally, we were unable to provide evidence to explain why dogs followed third party pointing more often when it was inaccurate than when it was accurate. While we conjectured that inaccurate pointing may trigger a violation of expectation in dogs, we were unable to find patterns in the data to support this conclusion and did not obtain looking time data that may have been a useful measure of heightened attention to the pointing.

This experiment found evidence to support the hypothesis that dogs interpret pointing as a weak command that conveys information, but these data by no means exhaust what it means for a dog to interpret pointing. Questions persist about the extent to which such interpretations can be considered conscious, the potential distinction between dogs *interpreting* pointing as information as opposed to simply *using* pointing as information, and the degree to which dogs resist ascribing a negative meaning—"*don't* go over there"—to pointing. Perhaps by delving into this peculiar proclivity to follow pointing we may be able to more fully elucidate one way that dogs mentally represent communication.

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a)

b)

Figure 1. Experimental set up for dogs in Studies 1 (a) and 2 (b).

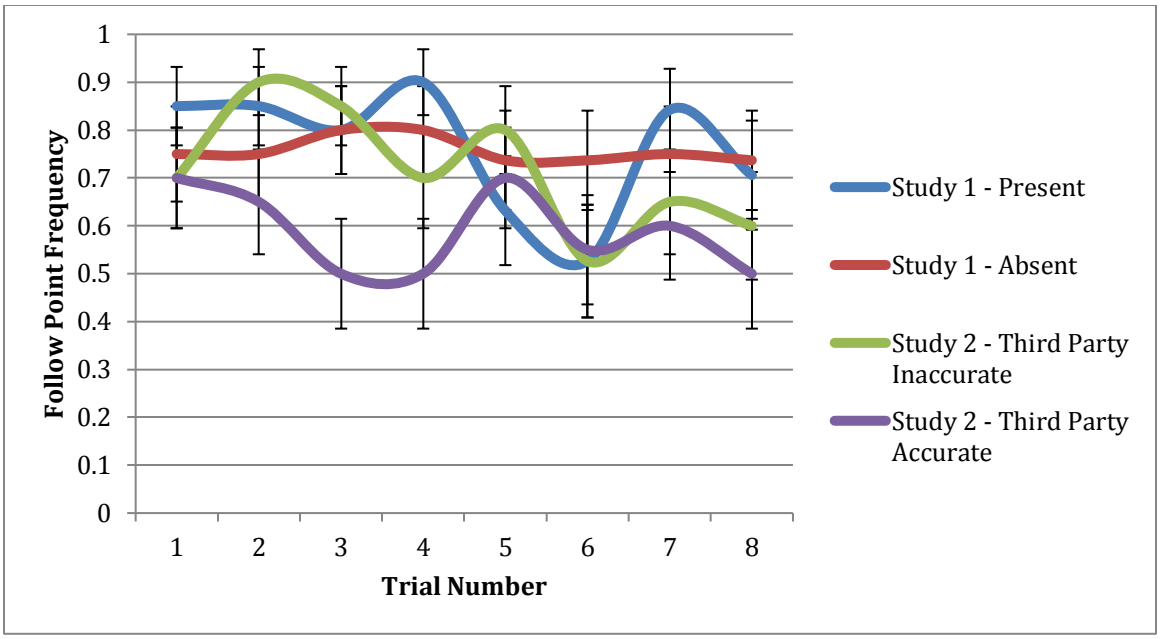

Figure 2. The frequency at which dogs followed pointing across trials for all conditions in Study 1 and Study 2. Error bars indicate standard error.

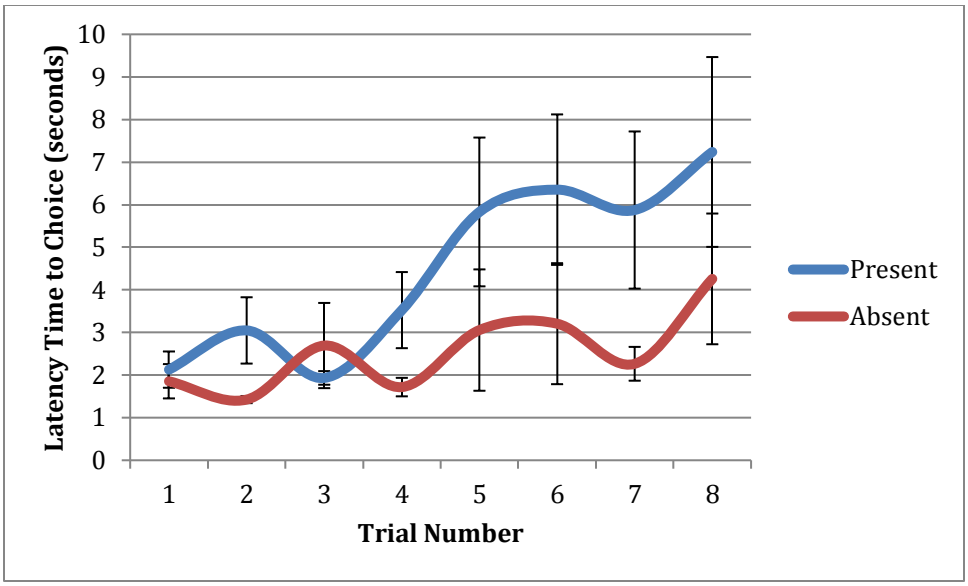

Figure 3. The distribution of latency time across trials in Study 1. Errors indicate standard error.

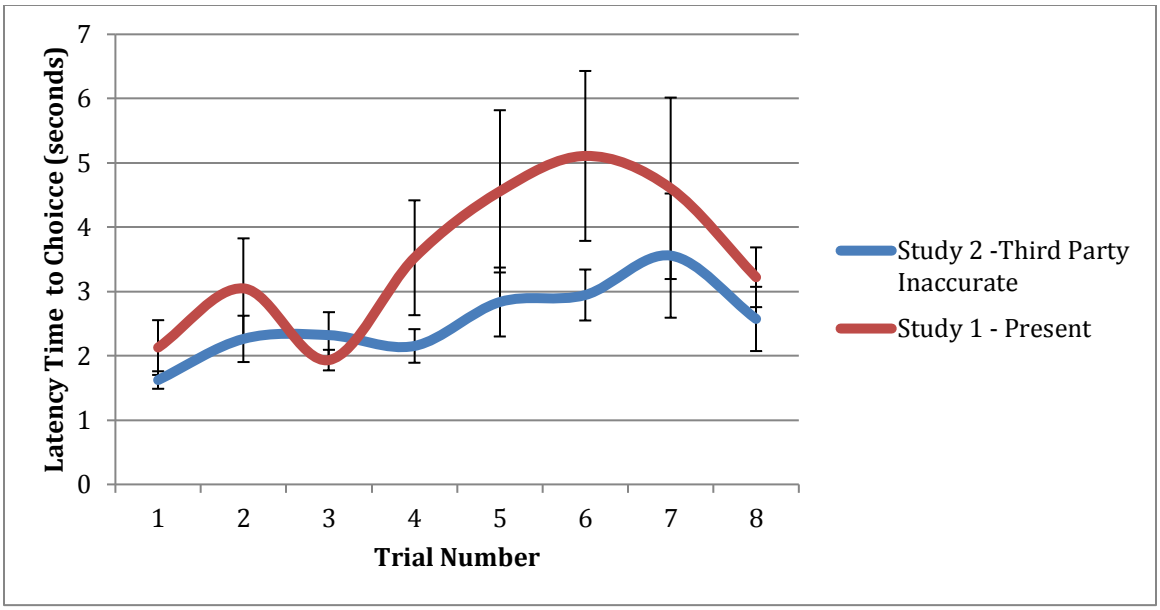

Figure 4: The distribution of latency time across trials in the inaccurate condition of Study 2 and the present condition of Study 1. Errors indicate standard error.