DO DOMESTIC DOGS RECOGNIZE EMOTIONAL INCONGRUENCE IN HUMAN FACES AND VOICES?

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INTRODUCTION

Dogs have been an integral part of human life since they were first domesticated more than 10,000 years ago. Via artificial selection, humans have forced the increase in behavioral traits in dogs (compared to their ancestors the wolves) that make them compatible with human social life. For example, dogs are tuned into human gaze direction toward hidden food, which is something that neither wolves nor the closest relatives to humans, chimpanzees, can do (Hare et al., 2002). Through a series of experiments, Hare and colleagues (2002) were able to support that this is a result of artificial selection processes and not developmental changes due to human rearing or an inherent ability among canines in general. If so, it would follow that dogs were also selectively bred for traits that might make them better able to a) differentiate among humans and b) distinguish visual and audio cues to human emotions (given that emotion is an indicator of subsequent behavior). Recent research in domesticated dog behavior and cognition has supported this idea.

Facial recognition and interpretation is one such adaptation that is beneficial to dogs in their interaction with humans. In 2009, it was shown that dogs exhibit the same left-gaze bias when looking at human faces that humans do (Guo et al., 2009). Dogs were more likely to inspect the left side of a picture of a human face, and generally spent a longer time looking at that side of the picture. Because dogs only demonstrated this gaze bias when shown pictures of human faces, not pictures of dog faces, researchers concluded that dogs may have evolved this behavior to aid in facial processing of their owners and the understanding of social interaction clues from humans. Indeed, in an earlier study, Adachi and colleagues (2007) concluded that dogs recognize the faces and voices of their owners, using an expectancy violation procedure. Pet dogs heard an audio recording of either the owner or a stranger calling the dog's name, followed by the display of a picture of either the owner or the stranger's face. Dogs looked significantly longer at the screen when the identities of the face and the voice were incongruent than when they were congruent, suggesting that not only do dogs recognize human faces and associate them with voices, but that they may generate an expectation of a visual stimulus in response to an auditory one.

Additional studies have been conducted regarding dogs' perception of human emotion, especially on the basis of facial expressions. Nagasawa and colleagues (2011) were able to train dogs to discriminate between smiling faces and blank faces, showing that dogs are receptive to differences in emotional facial expressions. Another group analyzed the behavior of dogs observing their owners watch either a happy or a sad movie. The dogs gazed longer at their owners when the owners felt cheerful than when they felt sad, which indicated that dogs may be sensitive to human emotional states (Morisaki et al., 2009). This finding was corroborated by the results of another study which used specific facial expressions as the only stimulus; Deputte and Doll (2011) found that dogs had a more significant reaction to emotional facial expressions than to neutral faces, measured by approach and avoidance behavior. Finally, dogs have also been shown to have variable reactions to audio characteristic of different emotions. Dogs responded differently to the same command depending on the tone of voice in which the command was given, and showed more interest in finding a hidden demonstrator when an audio recording of crying was played than when the audio was of laughter (Ruffman and Morris-Trainor, 2011).

As these connections between dogs and humans are further explored, questions arise about just how much dogs perceive about humans and our emotions. Our objective was to build on previous experiments and, in particular, we were interested in whether or not dogs used multiple cues to human emotions simultaneously. If so, we predicted that they would be more interested in anomalous pairs of cues than when two different cues matched. Specifically, we used an habituation-dishabituation procedure to test whether dogs recognize incongruence between emotions displayed on human faces and emotions expressed in human voices.

MATERIALS AND METHODS

A population of 34 shelter dogs was tested at the Richland County Dog Shelter and Adoption Center in Mansfield, Ohio. In each of the two treatment groups, there were nine female dogs and eleven male dogs of a variety of breeds and sizes. The majority of dogs were between one and five years old (Table 1) and age distributions were fairly evenly distributed between our two main trials. Dogs were chosen at random, but aggressive, fearful, and overactive dogs were avoided.

All trials took place in the same adoption room, during four visits over a period of 24 days. The three ‘handlers’ were college-aged women, two of whom also acted as ‘demonstrators.’ The ‘observer’ who operated audiovisual equipment was a college-aged man.

Before testing, each dog underwent a socialization period in the testing room with the handler and observer. Once the dog became acclimated to the environment, the observer moved to the back of the room (Fig. 1) and a demonstrator entered the room and sat in a chair facing the dog and handler. Although dogs interacted positively with the handler and observer before each trial, and received attention and food rewards after each trial, all parties refrained from making eye contact or otherwise interacting with the dogs during testing itself. Handlers did not instruct or position the dogs except to restrain them from jumping on the demonstrator, disturbing equipment, or moving out of the visual field of the video camera.

Audiovisual equipment consisted of a laptop computer and portable speaker set up on a folding table directly behind the demonstrator’s chair, and a video camera on a tripod to the left of the table (Figure 1). The demonstrator displayed either a happy or a sad facial expression while looking in the direction of, but not directly at, the dog. Simultaneously, an audio recording of the congruent emotion, either infant laughter or infant crying, was played. Methods mimicked those of Adachi and colleagues (2009), but differed in the use of a human demonstrator instead of an image on a screen, as well as the presentation of auditory and visual stimuli simultaneously instead of separately.

Once the dog showed a marked decrease in attentive responses (habituation) after a minimum time of 30 seconds, one of two changes occurred to induce dishabituation. In the Congruent-Congruent trials (C-C, N=20), both the facial expression and the audio recording changed to create the other congruent pair (e.g., happy face-happy voice became sad face-sad voice). In the Congruent-Incongruent trials (C-I, N=20), either the facial expression or the audio recording changed to create an incongruent pairing (e.g., happy-happy became happy-sad).

The dogs' reactions were measured as changes in gaze, ear and tail position, posture, and vocalizations. Gaze was noted as any event in which the dog looked at the demonstrator's face for two seconds or longer (glancing at the demonstrator was noted but not counted in cumulative gaze time calculations).

Of 34 total dogs, 28 dogs participated in one of six trial combinations (Table 2). The six remaining dogs were tested twice, taking part in one C-C trial and one C-I trial with at least one week between trials.

RESULTS

All Dogs Combined: There was no change in whether or not subjects gazed at the demonstrator in the C-C trials; ten dogs gazed at the demonstrator during the initial combination, while seven exhibited gaze in the second combination. However, the mean gaze time decreased from 7 s to 5.4 s, as predicted if subjects were habituating. Looking at individual subjects separately, four dogs showed an increase in gaze time (mean= +2.2 s) and eight dogs showed a decrease (mean= -5.1 s) (Figure 2). Eight dogs did not gaze at the demonstrator in either combination.

There was also no change in whether or not subjects gazed at the demonstrator in the C-I trials; eight dogs gazed at the demonstrator during the initial combination, while six exhibited gaze in the second combination. However, the mean gaze time increased from 5.6 s to 10.5 s as predicted if the subjects were dishabituating. Looking at individual subjects separately, four dogs showed an increase in gaze time (mean= +12.8 s) and seven showed a decrease (mean= -4.7 s) (Figure 3). Nine dogs did not gaze at the demonstrator in either combination.

In the C-C trials, 90% (N=18/20) of the dogs exhibited approach behavior in the initial combination, which decreased to 40% (N=8/20) in the second combination. Looking at individual subjects separately, 70% (N=14/20) showed decreased approach behavior in the second combination, six dogs had no change, and none increased. For the C-I trials, 80% (N=16/20) approached the demonstrator in the initial combination, decreasing to 35% (N=7/20) in the second combination. Looking at individual subjects separately, 60% (N=12/20) showed a decrease in approach behavior, seven dogs showed no change, and one dog showed an increase.

Vocalizations were noted during 4 of the initial combinations and 3 of the second combinations for the C-C trials. Looking at individual subjects separately, two dogs showed a decrease in vocalizations from the first to the second combination, and none showed an increase (i.e., 18 dogs vocalized the same in both combinations). In the C-I trials, vocalizations occurred in 5 of the initial combinations and 4 of the second combinations. Looking at individual subjects separately, 18 dogs vocalized the same in both combinations, one dog showed an increase in vocalization, and one dog showed a decrease. Both dogs that changed did so during transition from sad-sad to sad-happy combinations.

Although changes were noted in ear and tail positions, observers were unable to distinguish whether and which kinds of positions were stronger or weaker responses. In the C-C trials, four dogs showed a change in ear position in the second combination compared with the first. All dogs that changed did so during transition from sad-sad to happy-happy combinations. Three dogs showed a change in ear position from the first to the second combination in the C-I trials. All three dogs that changed did so during transitions when only the audio was changed in the second combination. Tail position changes were noted in three dogs in the C-C trials, and five dogs in the C-I group.

Subset of Dogs Tested Twice: In the subset of six dogs that were tested twice, results were consistent with the hypothesis and with those above. In the C-C trials, all six dogs showed a decrease in approach of the demonstrator, and two decreased their gaze time while four did not focus their gaze on the demonstrator for either combination. In the C-I trials, three dogs showed an increase in gaze time while two did not gaze at the demonstrator and one dog had an increase of 1 s. None of the dogs produced approach responses during either combination in the C-I trials.

Potentially Confounding Effects: We found no effect of age or sex on responses (Figures 4 and 5).

DISCUSSION

Our hypothesis was that dogs would have a stronger reaction to incongruent face-voice pairs than to congruent face-voice pairs. As predicted, cumulative gaze time did differ between the C-C and C-I trials. Even though within the two trials, the number of specific dogs that gazed at the demonstrator, showed an increase in gaze time, and showed a decrease in gaze time were approximately the same, the length of time spent gazing varied. The mean gaze time in the trials where the demonstration transitions from congruent to congruent decreased from the first to the second combination for those dogs that exhibited gazing behavior. This is a reduction consistent with habituation. Conversely, the mean gaze time in the trials where the demonstration transitioned from a congruent to an incongruent combination nearly doubled from 5.6 s to 10.5 s. This evidence for dishabituation (i.e., an increase in mean gaze time rather than a decrease or no change) suggests that the subjects may have recognized that the face they saw and the voice they heard were emotionally incongruent.

Additionally, although some individual subjects increased in gaze time during the C-C trials, the mean increase was very small (2.2 s) compared to the mean increase in gaze time of C-I trials dogs that increased their gaze (12.5 s). The increase in gaze time in the C-I trials was driven by the trials that transitioned from happy-happy to either happy-sad or sad-happy. This may be because the dogs were acclimated to interaction with "happy"-acting people (e.g., shelter employees, visitors interested in adoptions), and were more interested in the "sad" emotion because it was novel. In the C-I trials that began with the sad-sad combination, the dogs to whom a "sad" emotion was more novel were already habituated to it by the time the change to an incongruent combination occurred, which may be why the increases in gaze time were smaller for these groups.

Although there were no significant differences between the groups regarding changes in approaching behavior and vocalizations, the only increase in responses occurred in the C-I trials. The ear and tail positions changed a bit between combinations in both trial types, but these responses proved difficult to interpret.

Because the subjects in this project were shelter dogs, we were unable to proceed with our original schedule of testing each dog twice because dogs were frequently adopted out or transferred to another organization by the next week's visit. However, we were able to test six dogs twice, and the results of this subset were consistent with the findings outlined above for all dogs combined. This strengthened our confidence in our findings and suggested that results were accurate regardless of the number of tests administered to each dog.

The use of shelter dogs instead of owned dogs presented several potentially confounding effects. First, the breeds of the dogs were not controlled. While some dogs appeared morphologically to be purebred, many were clearly mixed breeds.

Because we were not able to choose subjects from one breed exclusively, we instead attempted to obtain a large and random sampling of dogs from a variety of breeds. We found no relationship breed or category of breed and reaction to the demonstrator. We were better able to evenly choose among dogs based on age and sex and we found no relationship with these variable and subject responses.

A second issue with shelter vs. owned dogs is that there is a largely unknown history of the shelter dogs. Many of our subjects may never have bonded with a human before, whereas owned dogs may be more attentive to humans because they live with and interact with humans every day. Thus, our results might be confounded if some reactions are influenced by human-canine relationships on canine cognition and behavior. If so, owned dogs might have allowed us more control over this confounding effect. However, the effects of domestication might be present in all except feral dogs.

The final potential consequence of using shelter dogs was is the effect of the shelter environment on the dogs' attentiveness. The length of time that the dogs' had been at the shelter was uncontrolled, and a long stay at the shelter could impact a dog's reaction. For example, many are simply energetic and excited to interact with a new person, to go outside, to go into a new space other than the kennel. This had an obvious effect on the dogs as many were often more interested in the handler than in the demonstrator. Also, a stray dog that is new to the shelter and has never interacted with humans may be more stressed and more wary of humans than a dog that has been at the shelter for a longer period of time and has experienced positive human interaction, thus the reaction may be less attentive for the “newer” dog. Although we attempted to carefully avoiding using very nervous, aggressive or energetic dogs, we were unable to entirely control this potentially confounding effect.

IMPLICATIONS AND FUTURE EXPLORATION

Our results support the idea that dogs use multiple cues to interpret human emotion, and that they do so by associating characteristic expressions with appropriate sounds. One area of dog behavior that may be affected by this recognition of human emotion is “free choice.” Dogs’ choices of who to approach, what toy to play with, which treat to choose, or how to behave could be impacted by their interpretation of the emotional states of the people with whom they interact. This may also have implications in the training of both pet and assistance/therapy dogs. For example, pet dogs are often subject to “mixed signals” from owners who are inexperienced in training methods. Additionally, assistance and therapy dogs are selected for their abilities to be attuned to humans’ needs. Often, that involves being attentive to the master’s state of mind, as in dogs who assist people with post-traumatic stress disorder, panic disorders, or even diabetic persons who are warned by their dogs of oncoming hypoglycemia.

In the future, it would be beneficial to corroborate these findings using more controlled parameters. Testing a group of owned dogs that are of one breed and similar ages, in a setting void of the background noise typical of animal shelters, may yield a more authentic measure of the effects of human artificial selection.

CONCLUSIONS

Attentive dogs in the present experiment gazed longer and had a greater increase in gaze time when the presented face-voice combination was emotionally incongruent compared to congruent combinations, supporting our hypothesis that they would have a more significant reaction to incongruence. Given that dogs exhibit a longer gaze time when their expectations are violated (Adachi et al., 2007), our results suggest that dogs are simultaneously attentive to multiple cues to human emotions.

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APPENDIX A. Tables and Figures.

Age of Dogs	Dogs in C-C Trials	Dogs in C-I Trials
0-5 months	1	1
6-11 months	0	4
1-5 years	18	15
6+ years	1	0

Table 1. Age Distribution of Trials in Congruence-Congruence (C-C) and Congruence-Incongruence (C-I tests)

Number of Dogs	Habituation Combination		Dishabituation Combination	
	Face	Audio	Face	Audio
10	H	H	S	S
10	S	S	H	H
5	H	H	H	S
5	H	H	S	H
5	S	S	H	S
5	S	S	S	H

Table 2. Sample Sizes for Two Trial Combinations (H= happy face or voice, S= sad face or voice)

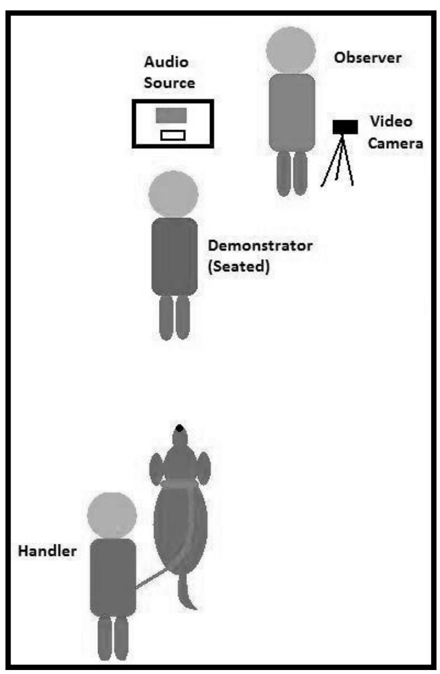

Figure 1. Experimental Setup

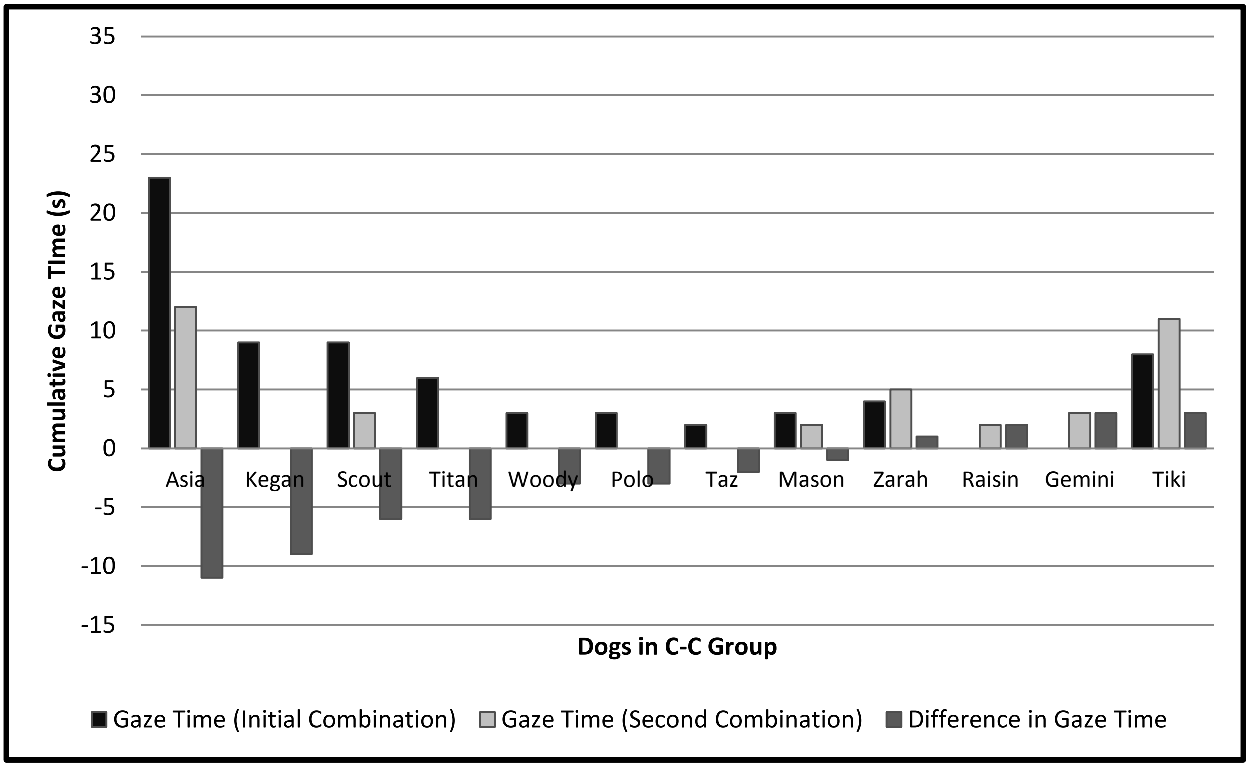

Figure 2. Gaze Time of Dogs in Congruent-Congruent Group

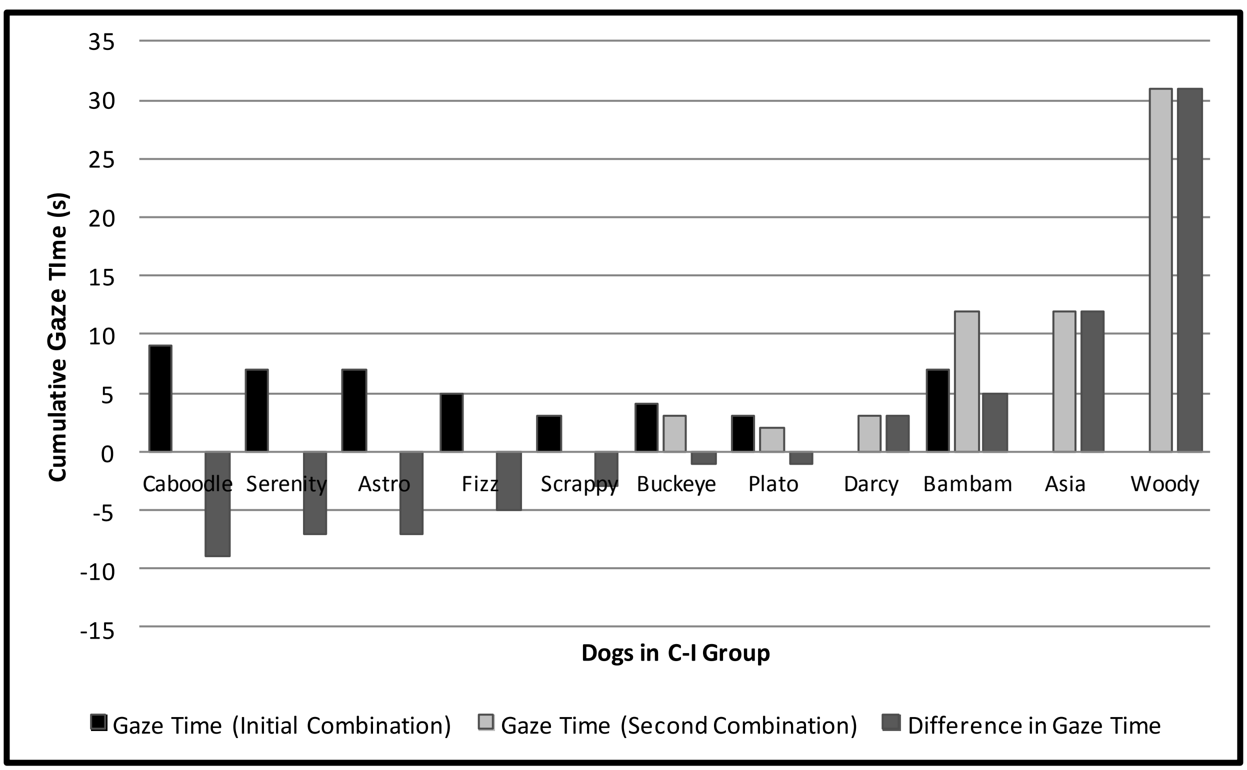

Figure 3. Gaze Time of Dogs in Congruent-Incongruent Group

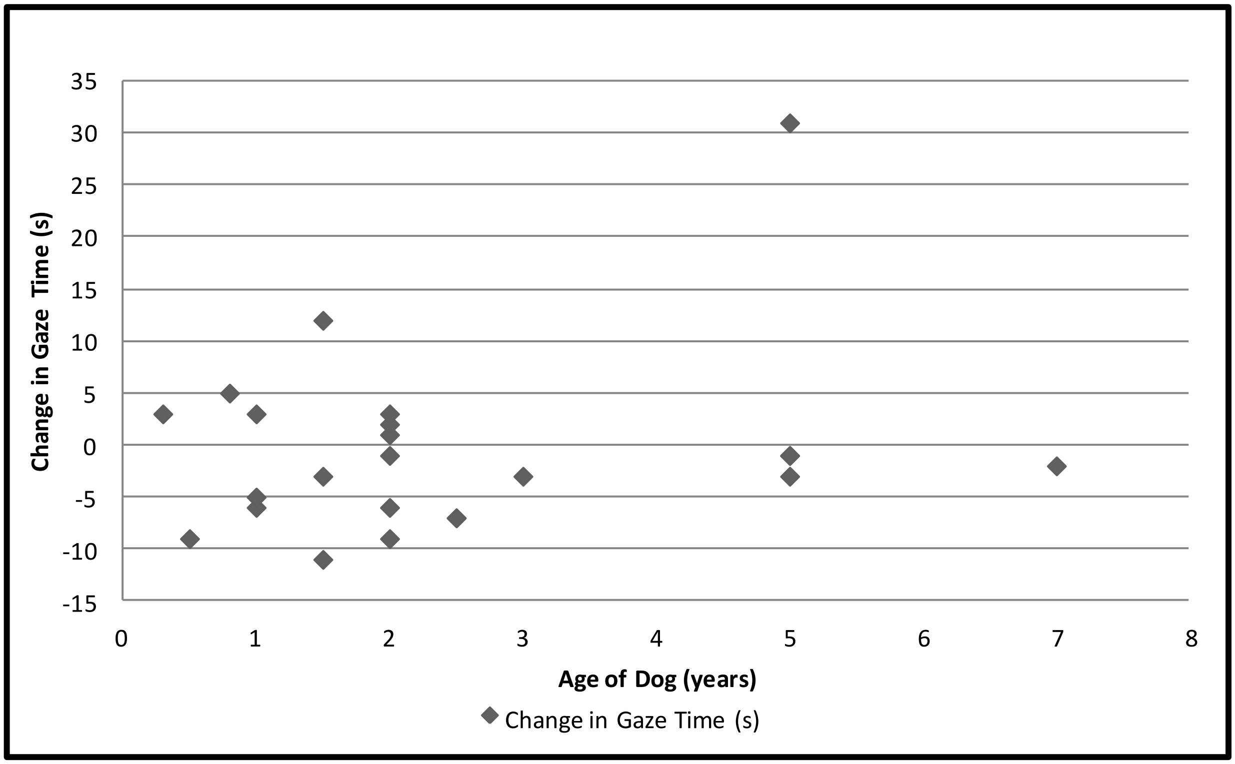

Figure 4. Relationship of Age and Gaze Time

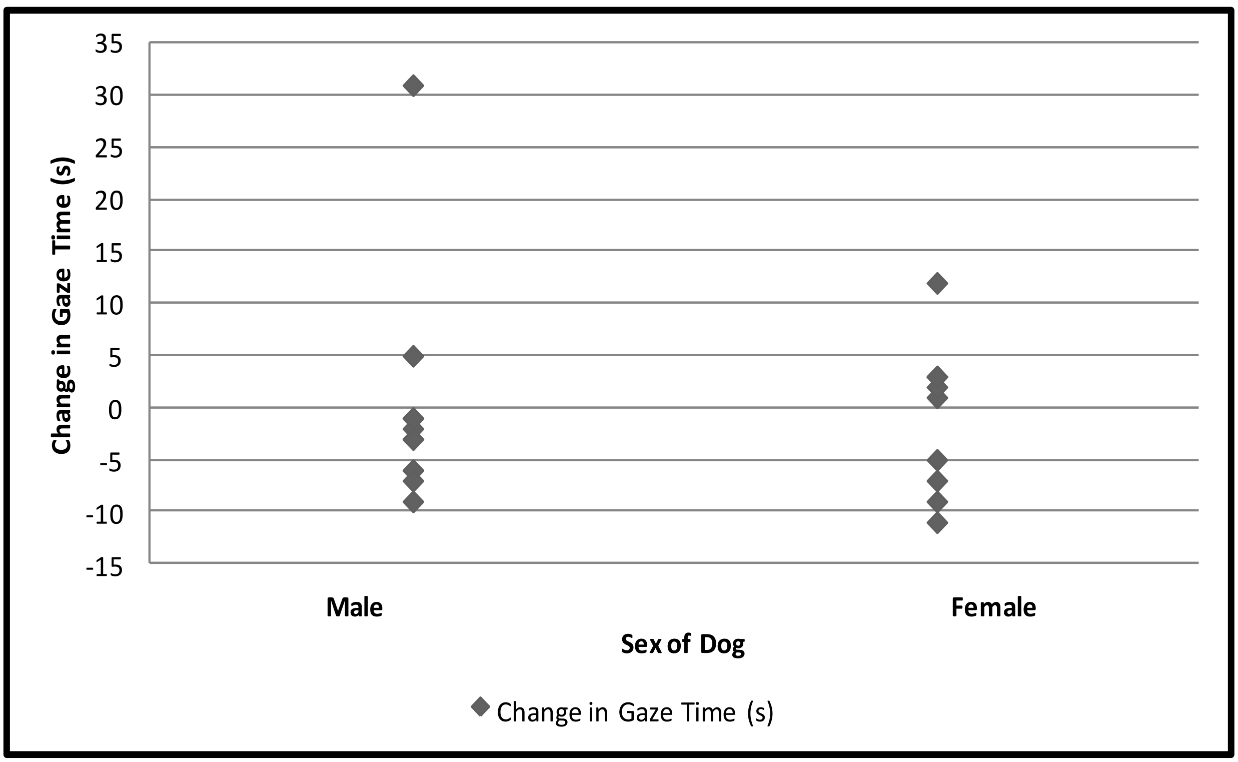

Figure 5. Relationship of Sex and Gaze Time

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