Cross-modal Human Gender Discrimination by Domestic Dogs *(Canis familiaris)*

By

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Allegheny College

Department of Biology

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A Senior Comprehensive Project in Partial Fulfillment of the Requirements for a Bachelor of Science Degree from Allegheny College

I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code and to maintain the integrity of both myself and the College community as a whole.

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Pledge

Approval by the Senior Thesis Committee:

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Dr. Lee Coates

Abstract

Domestic dogs have been a part of human lives for 15,000 years. They have shared our space and have developed many abilities over time that we use to our advantage in our everyday lives. Their ability to categorize humans is something that has been recently questioned, but this topic remains under-investigated. In my experiment I tested what factors affect a dog's ability to differentiate between human genders. By using 15 dogs, 6 male and 9 female, I looked at their ability to recognize gender in pre-recorded voices, recognize gender in pre-recorded voices that had been modified, and recognize gender when their owner is one of the people they have to choose from and the recording played is of the owner's same gender. The subjects were split into groups dependent on their sex, their owner's gender, and the number of people they live with. I hypothesized that female dogs, dogs with male owners, and dogs living with three or more people would be better at discriminating human gender. Female dogs showed slightly better ability to choose the correct gender (66.67%, 44.44%, 44.44%) than male dogs (50%, 16.67%, 33.33%) for all three experiments, respectively. These results, however, were not significant. There was also no significant effect on the percentage of correct choices when compared to the number of people living with the dog. Although the results were insignificant I did find that in experiment two, there was a higher probability for dogs to make the incorrect choice (Prob= 0.62) than the correct choice (Prob= 0.38) when voices had been digitally manipulated up or down to simulate the voice of the opposite gender. This suggests that the pitch of a human voice does contribute to a dog's ability to differentiate between genders. I believe that had I had a larger sample size my results may have been significant.

Introduction

Domesticated dogs are said to be descendants of several ancestral gray wolf populations. It has been found that domesticated dogs share a large proportion of their mtDNA polymorphisms with their wolf ancestors (Tsuda 1997). Because of these genetic similarities, wolves and dogs tend to share many of the same physical and behavioral traits. Although this is true for many traits, wolves are not as close

to humans as dogs are and therefore do not behave the same around us. There are many specific behavioral trait differences between wolves and dogs in regards to their interactions with humans. Wolves tend to be more aggressive even to familiar people (Gácsi 2005). This is why dogs have been bred to eliminate these aggressive traits and are now more suitable for life with humans. The domestication of dogs has been said to have facilitated the cooperation and communication between dogs and humans (Hare et al. 2002).

Today, dogs are known as “man’s best friend”, but a lot of people don’t understand how far that saying actually goes. Dogs depend on humans for certain things, such as when food is out of their reach they look at cooperative humans for assistance. Wolves have also been found to look to humans for help in retrieving out-of-reach food, but dogs show a higher dependency on humans (Heberlein et al. 2016). It has now been demonstrated that dogs are able to communicate with humans in several paradigms including being able to read human communicative gestures such as a point and gaze cue (Hare and Tomasello 1999), or even using humans’ attentional states (Gácsi et al. 2004). Dogs can read us almost as well as we can read each other. They know when we are sad, happy, lonely, and some dogs can even help us do tasks in our everyday lives. Dogs have had a huge impact on our lives. Over time they have provided us with companionship, love, and protection.

Since their domestication, approximately 15,000 years ago (Savolainen 2002), dogs have taken on many different roles in our lives. Many people are starting to recognize the importance of the human-animal bond. This has led to many different programs being designed. One of those programs is dogs visiting nursing homes. The dogs go and sit with elderly men and women that are in these homes because they need help doing some everyday activities. These dogs visit with them and just let the elderly pet and love them, which has had a significant effect on improving the lives of the individuals in these homes (Kaiser 2002). Another job dogs have is a guide for blind people. These dogs act as the blind’s eyes and help them become more independent in their everyday lives. It has been found that

these dogs can give people increased confidence, and a more joyous life (Miner 2001). Other jobs for dogs include bomb and drug detection dogs for the police and the military, and also tracking dogs for when people get lost or a criminal needs to be found. They can be therapy dogs, which is good for people stuck in hospitals and especially college students. Dogs can also serve as search and rescue for people who get lost in the mountains or forests, and hunting dogs for finding and flushing out the desired animals for their human partners. But most importantly, they are companions not only for people in their everyday lives, but also for people suffering from depression, PTSD, or other similar disorders. There are many things that people can do now that would not have been possible without dogs.

Cross-modality is defined as the ability to integrate information from different sense modalities (Webster's Revised Unabridged Dictionary-1913). At one point in time, it was thought to be something only humans could do (Ettlinger 1967). Several studies done since then demonstrate the ability of non-human animals to recognize conspecifics cross-modally. Being able to identify social partners is critical to developing sophisticated relationships in social settings (Proops and McComb 2012). This ability to exploit cues from their social group members enables conspecifics to benefit from knowledge only possessed by specific group-mates (Hare and Tomasello 1999). Recently the idea that cross-modal recognition in non-human animals could extend to humans has been investigated. The very first experiment done on this topic tested horses and their handlers. Horses were played a recording of a familiar handler or owner while two familiar people (one being the same person as in the recording) stood in front of them cross-modally. It was found that domestic horses, especially female horses, are indeed capable of cross-modal recognition of their familiar handlers through both vocal and visual cues. This was the first evidence that animals are capable of cross-modally recognizing animals outside their own taxon (Proops and McComb 2012).

Only one other experiment on this topic has been published since then. It examined cross-modal discrimination in domestic dogs and whether or not they can discriminate between human genders. One of the major categorizations humans use when meeting new people is gender. We do this using visual and vocal cues, and it is possible that dogs are able to use the same cues to classify humans by gender. The dogs in this study were played an unfamiliar recording of either a man's or woman's voice while two unfamiliar people stood in front of them cross-modally. It was found that dogs living with more people were better at cross-modal recognition of human gender when using both vocal and visual cues (Ratcliffe et al. 2014). For my senior project I expanded on that finding and looked deeper at what factors actually influence a dog's ability to recognize a human's gender.

In my study I aimed to determine if dogs can discriminate between human genders. More specifically, I looked into what factors influence a dog's ability to recognize male and female human voices. One of the factors I took into consideration was the sex of the dog; is it easier for male or female dogs to differentiate between genders? Another factor was the gender of the primary owner; if a dog lives and/or listens to a male and/or female, will they be better at differentiating human gender? The last factor I considered was the number of people the dog lives and interacts with on a daily basis; will the dog be better at human gender differentiation if they live with more people?

I used three different treatments to help me answer those questions. The first was my control. I played the dogs a recording of either a male or female voice to determine if they were able to differentiate between the two genders. My second treatment was modified recordings. I took the pre-recorded voices and modified the males to be a higher pitch and the females to be a lower pitch. I then played the dogs a recording of either the higher pitched male voice or the lower pitched female voice. This was to determine whether the pitch of a voice is a factor that helps dog determine gender. I predicted that the pitch of the recording would affect the dog's ability to determine gender. For my third treatment I used the dog's owner as one of my assistants and played a recording of the same

gender as the owner. I used this treatment to determine if a dog can identify it's owner's gender even though the recording was not of the owner's voice. Overall, I hypothesized that female dogs, dogs with male owners, and dogs that live with more people would be better at discriminating between human genders.

Methods

Subjects

A total of 15 dogs of various breeds were recruited. I emailed professors and students throughout the Allegheny College community as well as posted an ad on the My Allegheny page. The dogs' owners responded to my emails and my post showing interest in participating in my study. I obtained a total of six male dogs and nine female dogs of varying ages, none of the dogs were less than six months of age. I was unable to get any male dogs with male owners. However, I did recruit six male dogs with female owners, two female dogs with male owners, and seven female dogs with female owners. The dogs were all healthy with no known aggression towards people. The dogs were housed with their families for the duration of the study.

Recordings

Three men and three women between the ages of 17 and 23 were asked to make recordings of the following phrases: "Hey!", "Good dog!", "Come", and "What's this?" Each speaker said the phrases once, pausing between each one. The recordings were made in a room with no other noise, and they were recorded using a free recorder and sound manipulation software (Audacity) on an ASUS Transformer computer. The recordings were played through a Bluetooth speaker (ILive) for the experiments.

Experimental Set-up

Experiments were carried out during the 2018 Spring academic year in the Reis Hall basement, room 006, on the Allegheny College campus. The testing room was completely empty except for the speaker, camera, tripod, chair, and tape markers on the floor. The speaker and camera were placed on the opposite side of the room from the door. The chair was placed five meters away from the speaker, closer towards the door. A square made of tape on the floor in front of the chair designated where the dog needed to be during the experiment. Brightly colored tape was placed along the floor from the outside middle of the square to the middle of the speaker (Figure 1). This tape was to provide a visual determinant of a left or right look by the subject on the video recording. This made it easier for me to determine the direction the dog looked when I analyzed the recorded videos.

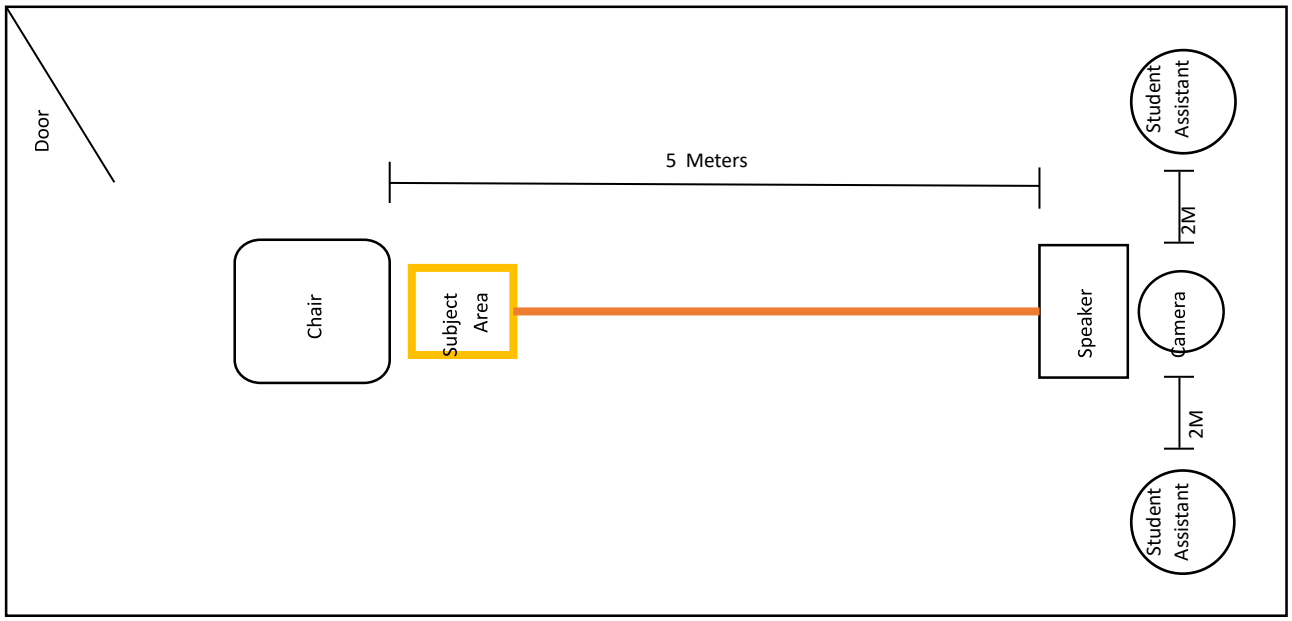


Figure 1: Pictorial representation of experimentation room.

For the first experiment two student assistants, one man and one woman, stood facing the subject approximately 2 meters on either side of the speaker (Figure 1). The assistants did not look at the dog, and instead stared straight ahead with a neutral expression on their face. The side on which the

man and woman assistant stood was randomized for each subject in each experiment. The assistants were randomly chosen from the pool of six that was used for the recordings and a few other stand-ins that were used when needed. The second experiment was set up the exact same way as described above. The third experiment was also set up the same, except that one of the assistants was the dog's owner and the other assistant was a student of the opposite gender. This setup was repeated for all 15 dogs.

Procedure

The room was set up as described above and the assistants took their places before the subject entered the room. The subject was then brought into the room and allowed to explore and become familiar with the equipment and assistants, but the assistants were not allowed to interact or speak to the subject. The owner, or helper, then lead the dog over to the designated area, sat in the provided chair, and placed the dog in front of them facing the speaker, camera, and assistants. Many of the dogs did not cooperate and sit still, so adjustments were made when analyzing the videos. The owner, or helper, was asked to stay silent and still. After settling into position the subject were given another ten seconds to visually familiarize themselves with the assistants. The procedure described above stayed the same for all three experiments.

Once the above procedure was done the voice recordings, as described above, were played. For experiment one, a single playback of a randomly assigned recording was played. This was to test if the subjects could correctly match a female or male voice to the assistants. For experiment two, a different recording was used but this recording was modified to either a higher pitch for male voices or a lower pitch for female voices using free sound manipulation software (Audacity). The pitch of the recordings were reduced or increased by 25-50% for deeper and higher pitches, respectively. Exactly how much the recording was modified varied depending on how they sounded. This was to see if the pitch of the voice

recordings was what determined a subject's ability to correctly match the voice to the assistant. For experiment three, the subject's owner acted as one of the assistants. The voice recording played was of the same gender as the owner but was not the owner's voice. This was to see if the subject can correctly match the gender of the recording even though it was not the owner's voice. The gender of the playback voice and the side on which the correct assistant stood was randomized for each experiment. The three experiments were done in the same order for each test subject.

Data Collection and Analysis

Prior to the experiment the owners were asked to fill out a short questionnaire about their dog. The questionnaire included general questions such as the dog's age, the dog's breed, the dog's sex, their own gender, the number of people the dog lives with, how much time the dog spends with people each day, and the origination of the dog (either animal shelter or private breeder).

The video recordings for each dog were analyzed and data was collected for correct and incorrect responses. I analyzed the videos by observing the direction the dog looked. For each experiment it was recorded which side each assistant stood. Many of the dogs looked in both directions, so the first look was the one recorded. A correct response was defined as toward the correct gender of the recording, regardless of if it was modified of not. So if a female voice was played the correct response was toward the female, even if the recording had been modified to be a deeper pitch; and if a male voice was played the correct response was toward the male, even if the recording had been modified to be a higher pitch.

Results

Analysis of the videos for experiment 1, control, showed a higher probability of correct responses (Prob= 0.64) than incorrect responses (Prob= 0.36). Of the 15 dogs, 9 choose the correct human gender, 5 dogs choose the incorrect gender, and 1 dog showed no response to the recordings

(Table 1). However, there was no significant difference in responses (P= 0.21). On average, dogs of age 4 and above showed higher likelihood of choosing the correct gender in experiment one (Table 3). As for dog sex, males and females had about the same average response with females (66.67%) showing slightly higher than males (50%) in correct responses (Table 2).

For experiment 2, manipulated, analysis showed a higher probability of incorrect responses (Prob= 0.62) than correct responses (Prob= 0.38). Eight dogs chose incorrectly, 5 dogs chose correctly, and 2 dogs showed no response. These responses were also not statistically significant (P= 0.40). Female dogs tended to show a greater ability to choose the correct gender (44.44%) than male dogs (16.67%) (Table 2). However, there was great variability between correct responses and dog age for experiment 2 with a slight favoritism toward older dogs (Table 3).

Experiment 3, owner gender, analysis showed a higher probability of correct responses (Prob= 0.75) than incorrect responses (Prob=0.25). 6 dogs chose correctly, 3 dogs chose incorrectly, and 5 dogs showed no response. Again, there was no significant difference between responses (P= 0.15), and a slight favoritism for correct responses was shown for older dogs, but there was great variability between ages (Table 3). Dog sex was also very similar with females (44.44%) showing slightly higher ability to choose correctly over males (33.33%) (Table 2).

In all three experiments, there is no significant difference between the number of people the dog lives with and their ability to differentiate gender. There was also a wide difference between dogs who live with the same number of people, as well as between dogs who live with more people versus less people (Table 1).

When comparing the control and manipulated experiments, there was a slightly higher probability of having a correct response in the control experiment (Prob= 52%) than in the manipulated experiment (Prob= 48%). However, there was no significant difference in the number of correct results

(χ^2= 0.18). These results are also shown in Figure 2. When played a recording of their owner's gender while the owner acted as an assistant, the dogs showed no significant difference in correct choice(χ^2= 0.43). As shown in Figure 3, however, there was a higher probability for dogs to make the correct choice (Prob= 75%).

Table 1: Dogs tested, their sex, ages, owner genders, the number of people they live with, and the responses they gave in all three experiments.

Dog	Sex	Age	Owner Gender	Number of People Lived With	Exp 1 Correct	Exp 2 Correct	Exp 3 Correct
Luke	male	3	female	2	no	no	no
Neeko	male	9	female	4	yes	yes	yes
Carter	male	4	female	1	yes	no	no response
Leia	female	6	female	2	no response	no response	no response
Luke	male	6	female	2	yes	no response	no
Bianca	female	13	female	3	yes	no	yes
Milo	male	8 mos	female	5	no	no	yes
Sansa	female	5	male (transgender)	1	yes	yes	yes
Stella	female	6 mos	female	5	no	yes	no response
Lingo	female	7	female	5	yes	no	no response
Baily	female	1	female	5	no	no	no
Ollie	male	5	female	2	no	no	no response
Libby	female	10	female	1	yes	yes	yes
Huma	female	2	female	1	yes	no	yes
Mya	female	4	male	3	yes	yes	no response

Table 2: Percent correct responses related to sex of the dog.

# of Dogs	Dog Sex	Exp 1 Avg Correct	Exp 2 Avg Correct	Exp 3 Avg Correct
9	Female	66.67%	44.44%	44.44%
6	Male	50%	16.67%	33.33%

Table 3: Percent correct responses related to age of the dog.

# of Dogs	Dog Age	Exp 1 Avg Correct	Exp 2 Avg Correct	Exp 3 Avg Correct
2	<1	0%	50%	50%
1	1	0%	0%	0%

1	2	100%	0%	100%
1	3	0%	0%	0%
2	4	100%	50%	0%
2	5	50%	50%	50%
2	6	50%	0%	0%
1	7	100%	0%	0%
1	9	100%	100%	100%
1	10	100%	100%	100%
1	13	100%	0%	100%

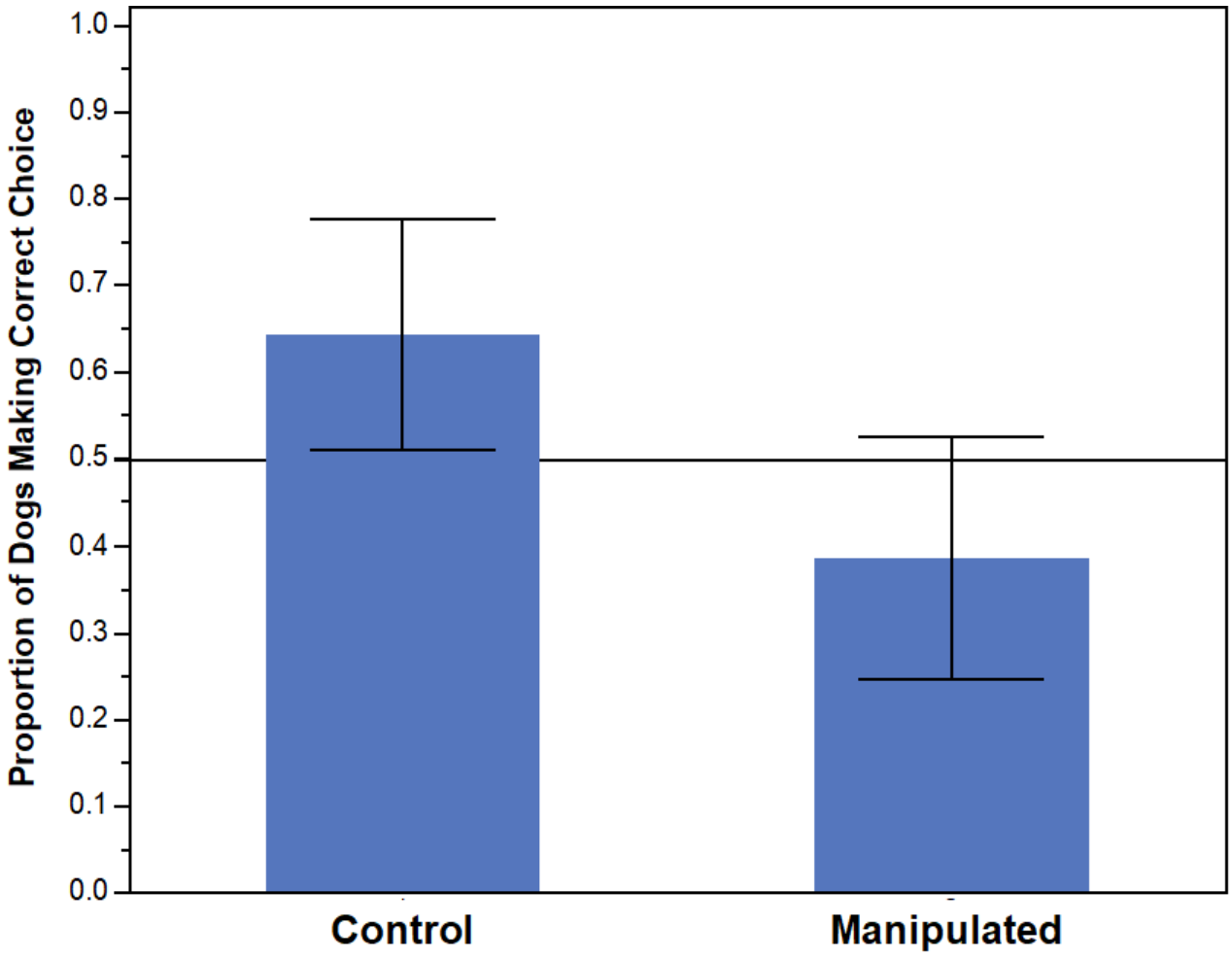


Figure 2: Proportion ± SE of correct choices made in control vs. manipulated experiments.

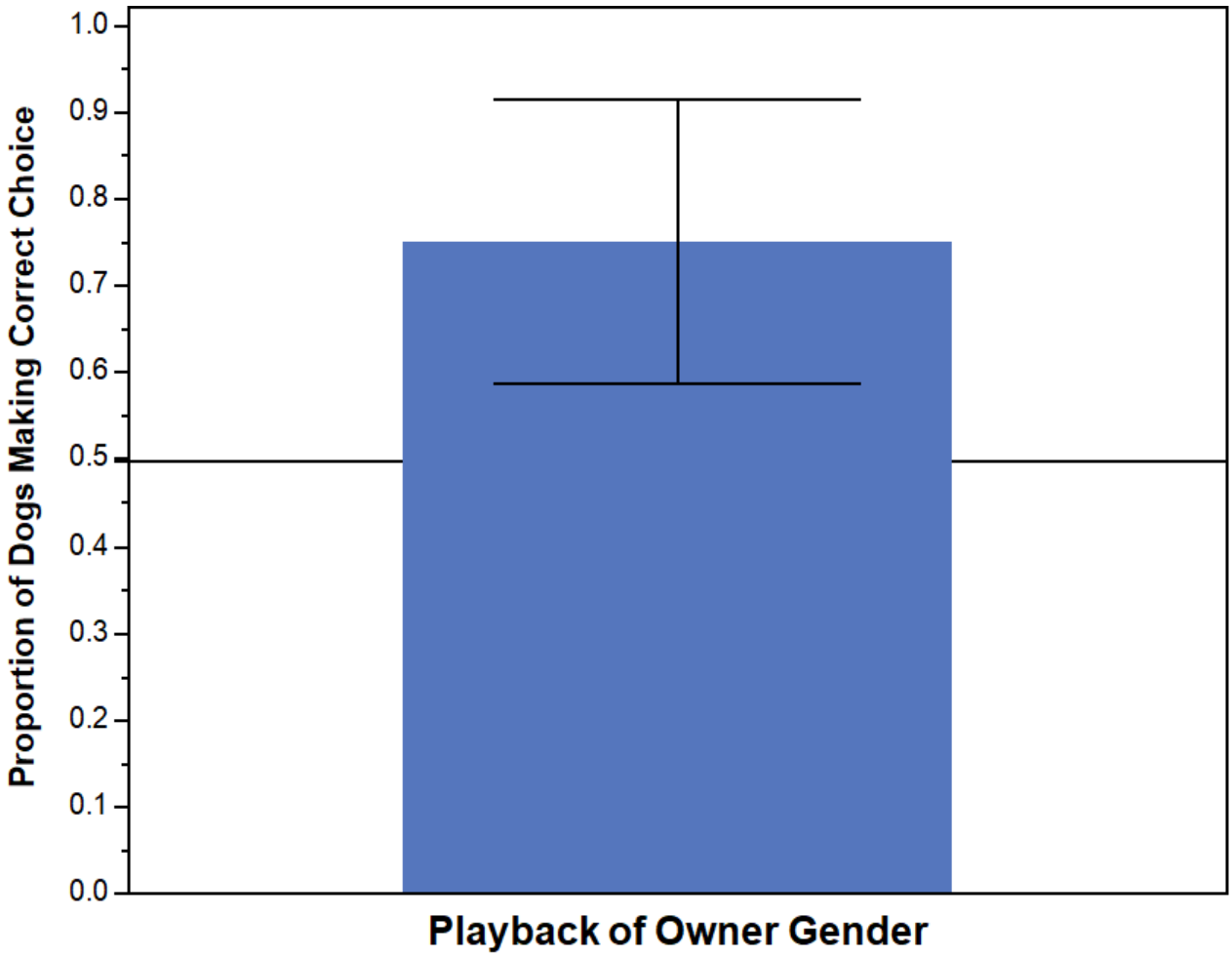


Figure 3: Proportion ± SE of correct choices made in owner gender experiment.

Discussion

I hypothesized that female dogs, dogs with male owners, and dogs that live with more people would be better at differentiating between male and female voices. Proops and McComb (2012) found that using both vocal and visual cues, horses were able to cross-modally recognize their handlers. By playing them recordings and having two people (one of them the handler) stand in front of the horse, the horse could positively identify it's handler based on a vocal recording. By modifying my recordings, I was able to test if the pitch of a voice was a factor in a dog's ability to differentiate between genders.

My results showed that this is a likely possibility. I found that when played a manipulated recording, dogs performed below chance levels (Table 1). The combination of the results from Proops and McComb (2012) and from myself suggest that our voices are a large factor in recognition of humans by animals. Also, I proposed that female dogs will be better because Proops and McComb (2012) found that female horses were better at differentiating between familiar humans. My findings were not significant but did show a slight favor towards female dogs (Table2). I believe that if I had a larger sample size I may have found significant results between the sexs of the dogs. I thought that dogs with male owners would have an easier time at differentiating between genders because of my own personal experience. My current dog, dogs that I have previously owned, and many dogs that I have interacted with seem to listen better to males. I think this is because of the deeper tone of voice that males naturally have. Unfortunately, I was only able to obtain two dogs with male owners for my study, so those results would not be effective in telling us anything. However, I found that in my control experiment dogs were more likely to make the correct choice when played a male recording (6 out of 8 times) than when played a female recording (3 out of 7 times). As for the dogs living with more people, I thought they would be better with voice differentiation because of Ratcliffe et al.'s (2014) experiment. In that study they found that dogs with more people in the house they live in are better at cross-modal recognition of human gender. My findings were not significant and showed no trend for the number of people the dog lived with.

I found that in my control experiment most dogs performed above chance levels (64% correct responses, Figure 2), suggesting that they can indeed differentiate between genders in humans. However, the results were not statistically significant. In my manipulated experiment, most dogs performed below chance levels (38% correct responses, Figure 2). This indicates that the pitch of the voice may be a determining factor in a dog's ability to recognize human gender. However, once again the results were not statistically significant. In my final experiment with the dog's owner as an assistant, the dogs performed above chance levels (75% correct responses, Figure 3) suggesting that even though

they know their owner's voice, they can still differentiate between genders. However, once again, the results were not significant. I believe that if I had a larger sample size, all of my experiments may have shown significant results.

If this experiment were replicated with a larger sample size and the results were found to be significant, it could be a big help to people who work with dogs on a regular basis. This will give people a better understanding of exactly how dogs differentiate and discriminate between humans, both familiar and unfamiliar. I have met many dogs that are afraid of humans, specifically men. The owners of these dogs have to work hard to gain their dog's trust enough for the dog to conquer their fear. If it is found that dogs with male owners are better at discriminating, that could suggest that men have a more authoritative and frightening voice to dogs. The owners of the frightened dogs could have a male come in and speak in a higher tone of voice toward the dog and that may show the dog that he is not as frightening as they think. Once the dog learns to trust that man, he could slowly deepen his voice back to normal and that could help the dog overcome their fear. This can apply to workers at dog shelters as well. If a dog comes in with high anxiety and is frightened, they could try talking in a higher pitched voice to try and relieve some of the anxiety. Shelters are already a stressful place for many dogs so if the workers can relieve some of that stress it would be very good for the dogs. Dog trainers could also use the results to their advantage. When they get a particularly hard case of a frightened dog, they could use this same technique of increasing their tone of voice. Also, if a trainer gets a dog that doesn't listen to them very well they could try deepening their voice to catch the dog's attention better. If my experiment were replicated with a larger sample size and the results come out to be significant, it could potentially help many dogs and many of the people that work with dogs.

Ratcliffe et al's (2014) analyzed their videos by using a centerline on the floor to measure the angle of a look. A look was defined as toward either of the assistants if the dog's head was between fifteen and twenty-five degrees. If the dog's look was five degrees or less from the center it was defined

as toward the speaker. Finally, if the dog's look was between six and fourteen degrees or was twenty-six degrees or more from the center, it was defined as away. To measure these angles, the center line of tape gave a general center orientation, but a line was drawn from the center of the dog's forehead to the center of its nose. This was to determine the orientation of the dog's head before a recording was played and helped when measuring the degree of the look after a recording was played. This method did not give an absolute measurement of the visual orientation, but it provided a repeatable and standardized method of measurement across the subjects for their experiment. I was hoping to use this same method in analyzing my results, but the dog's I used were uncooperative. Many of them moved around too much for me to determine the orientation before the recording was played. Also, many of the dogs did not stay in the designated box, so the centerline of tape on the floor did not provide a good reference for me. I believe that because I could not standardize the way I classified a look, and it was just based on my observations, this may have caused my results to be inaccurate.

Understanding how dogs can classify humans in their social setting will help us to better understand the relationship between domestic dogs and humans, which will in-turn strengthen the bond we already have. My findings illustrate that it may be possible for dogs to use both visual and vocal cues to cross-modally discriminate between human genders. The pitch of voices seems to be one of the factors that they use to classify us. However, additional studies with larger sample sizes are needed to test this hypothesis. If this hypothesis is found to be supported it will help us to improve on the programs already in place that use dogs to their advantage; such as therapy, guide, and police dogs. The bond between human and dog may be able to become stronger which will then improve the lives of not only the dogs but the people they are helping as well.

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