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Interspecies Communication in Homo Sapiens and Canis Lupis Familiaris: A Meta Analysis

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INTERSPECIES COMMUNICATION IN *HOMO SAPIENS* AND *CANIS LUPIS*

FAMILIARIS: A META ANALYSIS

by

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ABSTRACT

Interspecies communication is a fundamental aspect of many creatures. Knowing what another animal is saying could not only prove interesting, it could quite literally save a life. For humans, human-canine communication is arguably the most prevalent form of interspecies communication, and is important not only because of the close proximity of humans to dogs, but also because of the co-evolutionary aspects that have driven humans closer to "man's best friend". While there are some sources that allow for a consistent analysis of results in this field, it is still developing and constantly changing. A meta-analysis was performed to identify sources and causes of bias in articles, and to determine whether genetics and psychology were major influences on these articles. Small sample size and large variability of subjects negatively influences the impact that such studies have, but there are some that have been replicated and are more reliable. Review articles are the least biased, provide a good starting point for research, and are more likely to identify topics such as genetics and psychology in their analysis and discussion. Future scientists in this field should identify a standardized method of measurement, increase sample size, and repeat experiments multiple times to improve and refine the pool of data that is available.

To my doodle-dog and best friend, Rocky, and all of the other special furry creatures that touch our lives.

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First and foremost, I would like to thank my advisor, Clare Thomas-Pino, for helping to take an idea and formulate it to reality. This project began as a bright idea that had no idea where to go, and was guided by her to this final result. I would also like to thank the rest of my thesis committee: Brenda Kennedy-Wade, Deborah Levine, Rachel Snell, and Cynthia Erdley, for taking the time to read my thesis and provide constructive criticisms when necessary. Thank you to Aleksandr Kutchmarick, who sat through many iterations of papers and presentations, spent countless nights staying up with me, and supported me every step of the way. Finally, I would like to thank the staff and faculty of the Honors College at UMaine, who encouraged me to maintain and develop my critical thinking skills and keep my love of reading despite the hectic nature of being a STEM major in college.

FOREWORD

I have always been interested in the human-animal relationship. At parties, it was not uncommon to find me with the nearest animal, petting them rather than engaging in conversation with the other guests. Growing up, I always had animals, and bonded with them through many secret conversations and late night cuddles. This was particularly evident with our family beagle, Rocky. At six years old, I went with my mother to an unfamiliar house, and was told I could pick between two squirming puppies that were tucked under a man's arms. From that day, until the summer prior to beginning college, Rocky was my partner in crime. We caused shenanigans together, and I did everything from throwing snowballs at him during the winter to chasing him through the neighborhood while he playfully dodged my tackles.

A few years before he passed away, the family found out that Rocky had a rare heart condition whose name I could not pronounce, and that he would not live to be an old dog. This was part of the reason I decided to pursue Animal and Veterinary Sciences for my degree. Not only had animals been an influential part of my life from a very young age, but my childhood dog was suffering from a condition that would have been preventable had it been diagnosed at an earlier time. Despite my mother and father repeatedly telling the veterinarian that Rocky had chest sensitivities and a chronic cough, it was not discovered until the only course of action was treatment to make him more comfortable.

For me, dogs have always been family, and they have influenced others in many different ways as well. There are people who treat their dogs like children, and treat them like any other family member. Other people view them as working animals, training them

to perform tasks in the healthcare industry or to act as guides for their human caretakers. Still other canines sit firmly in the middle of these two categories, being a family pet while working as a therapy animal on the side. The world of human-animal interaction is expanding dramatically as more people realize that these animals positively influence day-to-day activities.

I decided on the topic of interspecies communication for my thesis on an unassuming rainy Sunday afternoon. I had heard many things about the movie *Blackfish* (2013), and sat down to watch it while the weather droned outside. *Blackfish*, a documentary about the killer whale Tilikum who killed his trainer and several others at the popular attraction SeaWorld, discussed many questions that do not currently have answers. The documentary went into detail about the natural lives of killer whales, and suggested that the relatively small enclosures the killer whales are kept in, as well as the repetitive tricks they must perform contributed to Tilikum's attacks. As a result of this documentary, thousands of people boycotted SeaWorld and petitioned for better treatment of the animals within its walls.

While the project I performed was not about killer whales, Tilikum's story contained some key questions. What do these animals feel? How do they communicate these feelings? Were there other signs of Tilikum's unhappiness before he killed his trainer? I continued to watch more documentaries on the subject, and found that while some research has been done in this field, it is still relatively unexplored. Humans are only just quantifying the bond with animals that they have shared for thousands of years.

My final thesis idea came from a combination of losing my dog, Rocky, and watching documentaries that dealt with animals in a unique manner. Documentaries such

as *Blackfish* opened my eyes to the world of interspecies communication as a scientific topic that can be quantified and studied. My experiences with animals, especially Rocky, shaped my development as a person due to the bond that we shared. Studies have been performed on other animals and their ability to understand and communicate with humans, but canines are more closely linked to our everyday lives than these other species. Performing a quantitative analysis on articles published on human-canine interaction promotes conversation about other species such as killer whales and others that we may not think of on such a regular basis.

For some, this research may seem superfluous. But as anybody who lives with or has worked with animals knows, coexisting with other species on the planet is critical for the survival of both parties. By understanding the implications of these interactions, humans can learn to not only work around other species, but to thrive with them and, in doing so, promote a healthy, sustainable planet.

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DEFINITIONS

The following definitions are terms that are used in the study. These may be important words that are critical for understanding the content of the articles, or they may be general terms that appear and are not well defined within the text.

Anthropomorphism- the attribution of human characteristics or behaviors to a god, animal, or object.

Attrition- A type of bias that results from incomplete data, such as removing a subject from a study partway through.

Bias- prejudice in favor or against a person, thing, or group compared to another. Bias is usually considered unfair and is not desirable.

Communication- the imparting or exchanging of information or news.

Dyad- something that consists of two elements or parts, such as a human-canine pair.

Ethogram- a catalog or table of all the different kinds of behavior or activity observed in an animal.

Genetics- The study of heritability and inherited characteristics, as in the DNA that makes up a genome of an individual. Used in this study as a mechanism for interspecies communication in humans and canines.

GRADE- Acronym for the Grading of Recommendations Assessment, Development, and Evaluation. Method of assigning a ranking to an article based on certain qualifications. In this study, used to assign a general rank based on bias.

Interspecies communication- a form of communication that occurs between two different species, such as between a human and a canine.

Meta-Analysis- A specific type of systematic review that combines data from multiple studies and quantitatively analyzes it to determine its effectiveness.

MOOSE- Acronym for Meta-analysis Of Observational Studies in Epidemiology. A method of formatting studies, typically in epidemiology, that adheres to certain standards. Adapted for use in this field.

PAQ- Acronym for Pet Attachment Questionnaire. A commonly used method of analyzing an animal's behavior through surveying the owner.

Psychology- The scientific study of the mind and its functions, especially in a given context. Used in this study as a characteristic of mental functions and similarities between humans and canines.

SYRCLE's risk of bias tool- Acronym for Systematic Review Center for Laboratory animal Experimentation's risk of bias tool. Used to identify and categorize common types of bias in animal studies.

Systematic Review- A type of study that collects all empirical data and utilizes it to answer a specific question. May be quantitative or qualitative.

INTRODUCTION

Communication is the foundation of all society. Language was developed as a way for individuals to express feelings, emotions, and directions to one another. From the earliest known cave drawings in Lascaux, France, to the complex symphonies of Beethoven and Mozart, communication is achieved through many different methods. Sound, sight, touch, and even taste can be used to communicate. While most people think of communication as verbal, body language as well as other sounds can contribute to this phenomenon.

In humans (*Homo sapiens)*, all of these occur regularly. For example, an infant child cannot yet speak, but its mother can easily distinguish between a cry for food or a dirty diaper. Of course, there is also language, which is used to communicate from a young age. Certain words and phrases such as "Hello" or "Ciao" are commonly known and therefore can be used to communicate with people all over the world. No matter what a person's nationality, gender, et cetera, it is possible to communicate with another person, even if it is at the most basal level. Similarly, humans and other animals communicate through various non-spoken methods.

Understanding how this communication occurs is vital for animal scientists in particular, because of the inherent dangers present in working with another species. Regardless of whether a person is working with an animal to achieve a task such as herding, or providing medical care to the animal, humans must be able to interpret and understand what an animal is attempting to convey. Ignoring simple signs like a growling dog (*Canis lupis familiaris*) can result in a bite, and an animal acting out of the normal

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can be a sign of a serious illness. Veterinarians and animal behaviorists base their entire careers on being able to interpret these signs and react accordingly, but for the typical person this may not come easily. However, due to the nature of the human-pet relationship, many people are aware, at least in part, of some ways that their animals communicate with them.

In nature, many species have learned to communicate with each other. One species of bird may make a call to alert others of impending danger, and a plethora of species will take to the sky. The predator may also hear this call, and redirect his efforts, or perhaps even take this as a sign that his hunting skills need to be further improved. Pack predators such as lions (*Panthera leo*) or wolves (*Canis lupis*) may deploy a decoy to redirect an animal from the herd and therefore make it easier to hunt. Communication between animals may be subtle, but it allows multiple species to interpret various nuances and alter their behavior accordingly.

The close proximity of humans and other animals is part of the reason interspecies communication is so important in animal science. The struggle of understanding how animals communicate is rooted in cognition. Historically, many instances of communication with animals were written off as mere anthropomorphism, or the tendency of humans to attribute human characteristics to non-human things. New studies have shown that many species are in fact intelligent and sometimes possess cognitive skills that far surpass that of humans (de Waal, 2016). Scientific experiments have been performed that demonstrate real results, and while there are still skeptics, it is important to note that the idea of animal cognition is more than just hearsay. However, it is important to determine if conclusions on this type of research are based exclusively on

real data, or if they are developed as a result of humans impressing their own beliefs on the subjects.

Humans have most readily achieved this type of unspoken communication through domesticated companions, particularly in dogs. In both domestic and working environments, humans work with dogs to display certain signals in order to aid understanding. A pet dog may run to the door and scratch to let the owner know that he wishes to go outside, or begin whining to indicate hunger. A service dog is trained to not only interpret the task with which it is assigned, but to alert the handler so proper action may be taken, such as a dog working with a diabetic signaling that the owner has low blood sugar. A herding dog must work with both humans and other animals, following the owner's directives to herd a flock of sheep or other livestock.

Understanding the causes of interspecies communication is important to further the comprehension obtained by humans in the working field. Especially with the rise of non-traditional therapy and the use of therapy dogs and other working animals in a wider variety of applications, communication is more important than ever. Critically investigating both previously published works and new material allows scientists to draw new conclusions about the working human-animal bond, and furthers the opportunity for collaboration with more species in the future.

Canines have long been associated with *Homo sapiens*, and have coevolved with humans as they transitioned from hunter-gatherers to agricultural peoples and beyond (Hare and Woods, 2013). In the past, it was believed that dogs behaved similarly to the wolf, their ancestor, and had a very straightforward pack hierarchy. However, direct observation of packs in areas such as Yellowstone National Park show a different story,

indicating a highly complex family system rather than a linear dominance scheme (Safina, 2015). Rather than having an alpha wolf, and a beta wolf, families follow different members depending on the situation and the activity going on during any particular day, much like humans. A family may look to one member for advice on learning how to fish, while they would consult another family member for help with homework. Wolf families have a much more fluid dynamic than previously realized, an approach which may seem radical at first, but actually makes sense from an evolutionary standpoint. This is particularly important as it demonstrates that even well known "facts" are being questioned and overturned. Furthermore, it appears as though animal intelligence has been seen as limited, preventing scientists from fully understanding how animals perceive others.

Past research has focused on comparing how different species react to human interaction to measure intelligence or "presence of mind" (Miklosi and Soproni, 2005). Presence of mind can be defined as a creature's ability to understand and interpret various stimuli and act accordingly to those stimuli. The problem with this method is the bias created by using human intelligence as a baseline of understanding. A famous quote, which some have attributed to Albert Einstein, has summed this up rather succinctly:

"Everybody is a genius. But if you judge a fish on its ability to climb a tree, it will live its whole life believing that it is stupid."

In other words, it is nearly impossible to judge one species of animal using an evaluation technique that was developed for another. This is one of the inherent issues with

investigating interspecies communication. For the purpose of this investigation, it is assumed that canines have presence of mind as determined by previous experimental data.

Recently, research has suggested that cognition in various species is dependent on how similar species are in terms of psychological and genetic development (Merritt, 2015). In other words, genetic similarities as well as psychological similarities account for the ability of some species to communicate with one another. In dogs, it is thought that they are genetically more similar to a human toddler than their wolf counterparts, which is why they get along with humans so well (Spady and Ostrander, 2008). By this, the author means that dogs share more of their genetic code with humans than with their predecessor. This is a significant statement, as it implies selective conditioning over an extended period of time, and may explain why humans and canines cohabitate so well. This, along with psychology, are both topics that are to be investigated in this research, in order to determine which subject, if any, has been seen to overlap more with the phenomenon of interspecies communication.

For this project, psychology is defined as the study of mental functions in canines and how they compare to humans. This means that any article that discusses the mental capabilities of canines to explain their communication with humans will fall under this category. Genetics is defined as the genomic similarities between the two as a result of coevolution over thousands of years. Simply put, this sorts articles into categories based on whether they address the mind or the makeup of the subjects they are studying.

Several methods have been developed to observe the psychology of human-canine interaction. Two common methods to test for communication and understanding between

humans and dogs are the ethogram (McGreevy et al., 2012) and the Pet Attachment Questionnaire (PAQ) (Zilcha-Mano et al., 2011). As mentioned previously, these methods of measurement are inherently flawed because they were developed using a standardized method of investigation that is common to humans but not animals. Both methods allow for a somewhat quantitative assessment of communication and attachment factors, but both focus mostly on the human response.

The Pet Attachment Questionnaire identifies a plethora of behaviors that an animal may exhibit and asks the owner to answer questions based on what is observed. One human may observe a behavior differently than another, which may also be entirely unique from what the animal actually attempted. This issue occurs in ethograms as well. Humans record the activities of the animal, but there is not much that can be done about the researcher's perception of an animal, other than repeating the procedure with new observers. Ethograms are particularly difficult to execute because the researcher's presence may influence the behavior of the animal, skewing the results drastically.

Other research has attempted to eliminate the type of bias created in the PAQ by specifically observing the response of the canine in a human-canine introduction. The results of this indicated that canines have varying personalities and that there is no general answer to how humans and dogs communicate (Gyori et al., 2010). However, this does not mean that communication does not occur, it simply occurs in varying manners, just like two humans may communicate differently than they do with others. Rather than writing this off as a failed venture, researchers continue to explore new ways to quantify human-canine interaction.

Researchers have also indicated other possible sources of bias in their results, and some have offered ideas for further research into the newly developing field (Rehn and Keeling, 2016). This bias needs to be identified and recorded so that researchers may attempt to eliminate this bias in the future. Part of this process is understanding the basis of communication in species, which will allow for more thorough interpretation of results and give a better understanding of how interspecies communication works between humans and canines.

The overarching purpose of this study was threefold. The objectives of this study were to review past literature on animal cognition and "presence of mind," assess the validity and effectiveness of current research procedures through analyzing bias, and to study the areas of genetics and psychology to come to a consensus on why interspecies communication occurs between humans and canines.

MATERIALS AND METHODS

Research was completed using the databases provided by the University of Maine, and paper articles and texts were acquired through Fogler Library and the MaineCAT book exchange system. Twenty-two research articles and other works were utilized for this project. Articles and other published works went through a two-step selection process. First, abstracts of potential articles studying animal behavior in regards to canines and humans were reviewed. These articles needed to include both human and animal subjects to be considered, as well as publication dates within the last twelve years (articles published prior to 2005 were not considered). Once articles showed these qualifications, full texts were obtained when possible. If it was not possible to obtain the full text of an article, it was omitted even if it had passed the first step of the selection process. Once obtained, articles were analyzed and data was collected and recorded in an excel program in a table format. Articles that reached the second step were also excluded from the study if the information in the articles was incomplete or unrelated to the topic of interspecies communication.

Articles selected underwent a systematic review (as described above) and consequential meta-analysis, or quantitative review of article data. First, articles were read and the table was filled out for each text selected. An abridged version of the type of style used for data collection is shown in Table 1. This table included basic information about each article, such as the number of subjects, experimental methods used, and other miscellaneous notes. The table also noted whether the study contained quantitative or qualitative data, and recorded whether it utilized information about genetics and/or psychology in the introduction or discussion.

After filling this out, the Systematic Review Center for Laboratory animal Experimentation's (SYRCLE's) Risk of Bias Tool for animal studies was utilized to identify several areas of bias that may be present, and if so, how severe this bias was (Hooijmans et al., 2014). This tool accomplishes this task by breaking bias down into multiple categories, followed by ten subcategories. These different categories can be identified in Table 2. This process was done in a manner similar to previously published meta-analyses, such as one by Pires et al. (2016). After collecting the data, variations of the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) and the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) tools were used to write the report (Sriganesh et al., 2016). This allowed the report to be written in a professional manner and followed protocols that have already been approved for use in this field.

Finally, conclusions were drawn based on the meta-analysis about what methods of study were the most successful in this type of research. Articles were given general rankings (good versus bad), depending on the amount of bias present as determined by SYRCLE's risk of bias tool. Articles were identified that provide a good starting point for continued research in the future. Many of these "good" articles were chosen based on the breadth and depth of the study, as well as the presence (or lack) of bias in the results.

RESULTS

A total of twenty two articles were examined for the meta-analysis. Of the twenty

two articles considered, two were categorized as meta-analyses, six were considered

review articles, and the remaining fourteen were experimental (Figure 1).

Figure 1:
Pie chart organizing articles by type (meta-analysis, review, experimental).

**Type of Articles Used**
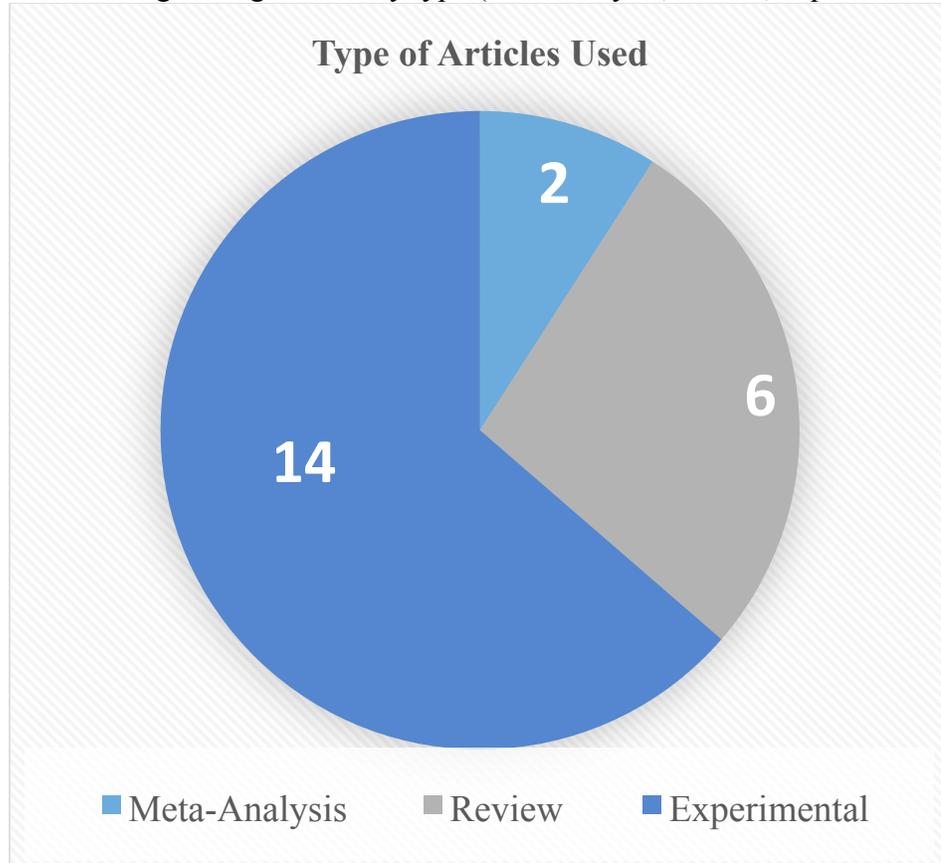
Articles had varying numbers of subjects, from as few as 6 canines (Udell et al., 2008) to

as many as 14,004 human-canine dyads (Kubinyi et al., 2009). The article utilizing

14,004 human-canine dyads was a significant outlier for sample size, and affected the

average number of subjects greatly (average with this value = 1,018 canines, average

without = 91 canines).

The two most common types of article were quantitative analyses followed by comparative articles (Table 3). Quantitative analyses focused on a variety of topics, including recognition of the pointing gesture in canines (Miklosi and Soprini, 2005), the quality of the relationship between humans and canines (Dalibard, 2009; Elgier et al., 2009b; Kotrschal et al., 2009; Lefebvre et al., 2007), and hormonal interactions (Handlin et al., 2011; Horvath et al., 2008; Jones and Josephs, 2006). Popular methods of data collection were questionnaires or surveys and experimental procedures. Review articles covered similar topics, but were able to expand and explore varying themes across a broad spectrum of experiments. The majority of articles (nineteen) explored psychology as a potential cause of human-canine communication, while only six addressed the possibility of genetic influence (Figure 2, Table 4).

Figure 2:
Venn diagram showing breakdown[a] of genetics vs. psychology in introduction/discussion of articles.
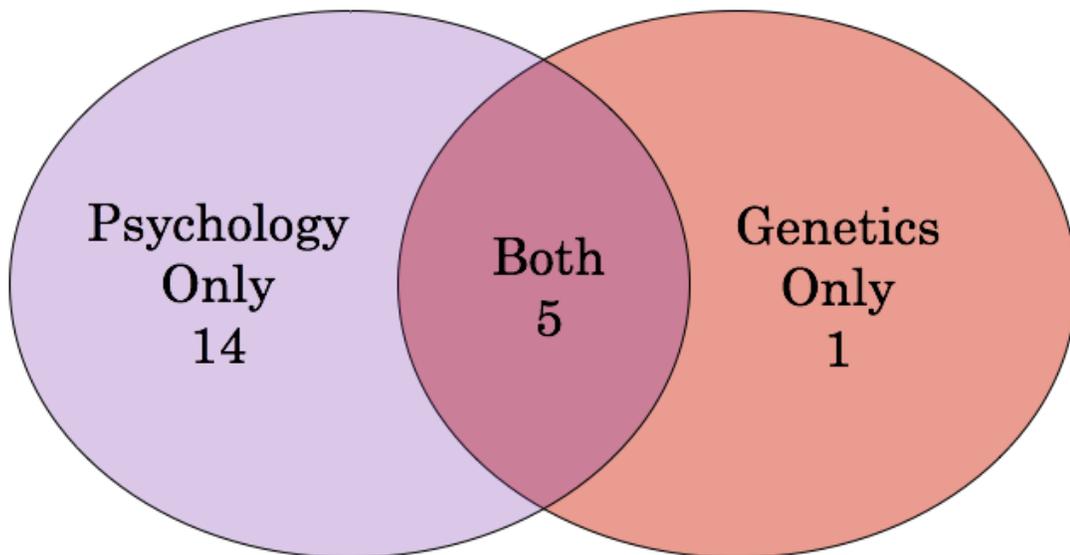
[a]Two articles did not discuss either one of these factors in their papers.

The GRADE system, a method of ranking articles based on a series of pre-defined

qualifications (Dijkers, M., 2013) and SYRCLE's risk of bias tool, which assigns bias

based on ten distinct subcategories (Hooijmans et al., 2014) were applied to each article

in order to qualitatively analyze them. While there is a computer program called

GRADEpro that facilitates this categorization available for purchase, it was not used in

the analysis of these results. When these methods were assigned to each article, it was

found that in general, review articles had lower bias "scores" than did experimental ones.

Table 5 shows each article and where, if anywhere, bias was noted.

Figure 3:
Bias by article, organized by author. Where first authors are the same, articles are ordered
by the way they appear in the reference list. (i.e. Elgier 2009a and Elgier 2009b).
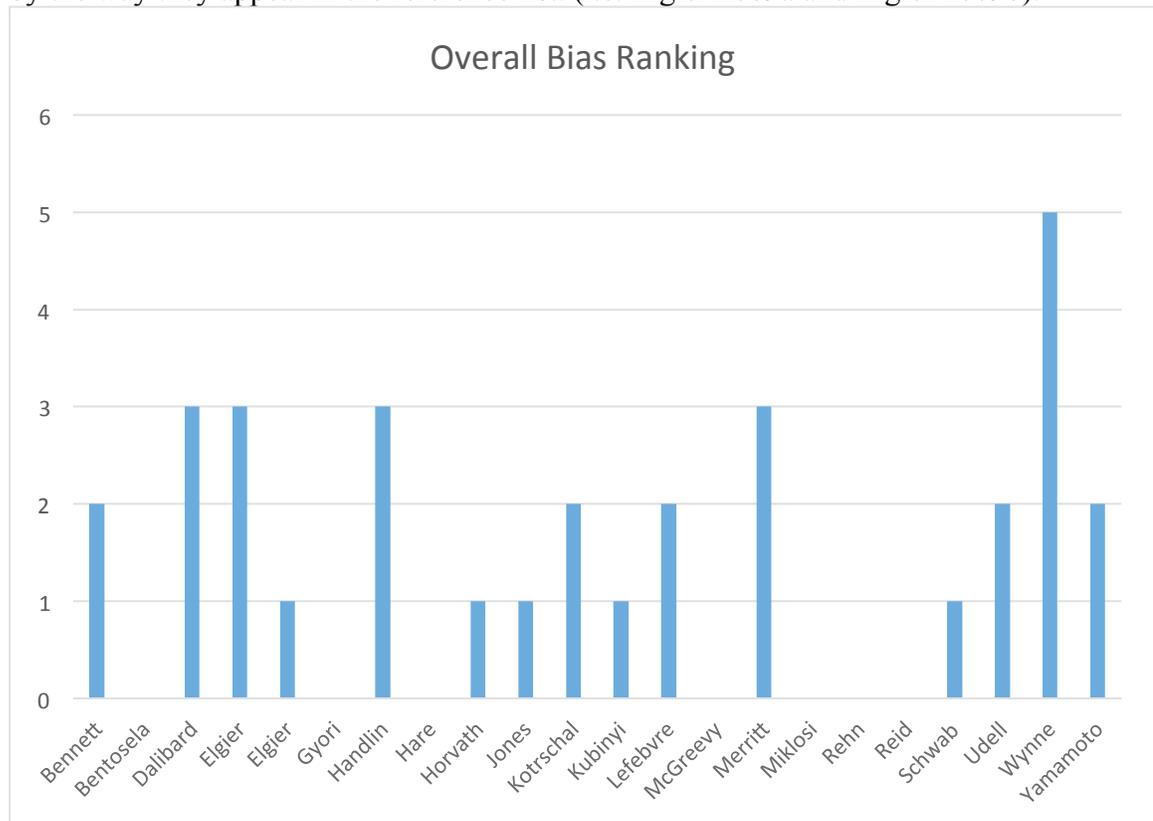
Bias was broken into five categories, which consisted of 10 smaller subcategories. For each category, a score ranging from 0 to 3 was assigned, with 0 being no bias and 3 being totally biased. Final score was the accumulation of these categories. The closer a score to zero, the less bias it possessed. Scores ranged from 0-5, with a mean of 1.45 (Figure 3). The most biased article was by Wynne et al., titled "Ontogeny's impacts on human-dog communication." This article received a bias score of 5 out of 30, due to a small sample size and not adequately discussing results. The most common areas of bias were attrition bias and reporting bias.

DISCUSSION

Bias Caused by Variability

Interspecies communication in humans and canines covers a broad spectrum of information. Part of the difficulty of isolating articles for the study is the breadth of topics covered under interspecies communication. Originally, the goal was to find articles that contained both human subjects and canine subjects and evaluate each on a similar scale. However, many of the articles that were actually included focused primarily on the canine reaction to various human stimuli. This is still important to address, as the human understanding of stimuli is much more understood than that of our canine counterparts. The variation in article structure opens the possibility for bias to occur through inconsistent testing methods. As mentioned in the introduction, this reaffirms the need to have a standardized method of experimentation for this type of science that will make it easier to replicate and evaluate studies in the field.

There are dozens of variables that make isolating the cause of results difficult. Many articles that were analyzed used inconsistent breeds, ages, or genders of canines, which left them vulnerable to bias. Some articles attempted to find correlations between factors such as owner personality and other demographic variables, such as in Bennett and Rohlf (2007). According to this study, problematic behaviors were associated with a variety of characteristics on part of both the canine and owner. In general, the size of the dog correlated with whether they were perceived as well behaved. Small dogs were often seen as more aggressive and had behavioral issues. Authors noted that this may be due to the fact that larger dogs were more likely to have gone through obedience training due to their size and stature. Authors concluded that the perception of the animal's behavior was

influenced by both canine and human individuals (Bennet and Rohlf, 2007). This means that rather than demographics such as occupation and location being affecting factors, the personality and activity level of the owner determined the number of activities that the canine was involved in. Dogs were influenced by the personality and activity level of the owner, which is an extremely difficult factor to control in experimental situations.

This article and others also found that their results may have been skewed due to data collection methods, namely a survey that was voluntarily completed. As typically occurs in volunteer scenarios, respondents of these surveys have some sort of emotional investment in the outcome. It was noted that questionnaires such as this are often answered by people who are considered "dog-people," and may not provide a representative sample of the entire population. A person who loathes dogs but has experience with cats is not qualified to answer this type of survey, and people who do not fit the qualifications may constitute a large population which is therefore not represented. Other people may own dogs, but be unable to access the survey because they do not have the means to complete it, or do not view the survey of importance, choosing not to respond. Voluntary surveys also allow for the possibility of incomplete or partial answers that cannot be used to analyze data, such as in Lefebvre et al. (2007).

Still other researchers attempted to identify effects of very stringently defined parameters, such as with military dogs (Horvath et al., 2008; Lefebvre et al., 2007), particular genders (Kortrschal et al., 2009), and even canine age (Wynne et al., 2008). Many of these were successful in identifying correlations within the parameters that they defined, but the lack of a standardized method of systematically categorizing these results means that they are being underutilized or not utilized at all. Understanding the

relationship between canines and their handlers of the Belgian army in 2001 (Lefebvre et al., 2007) may be useful for other military-based dog programs across the country, but is limited to those animals that are involved in police work. This excludes millions of dogs that are in other capacities, such as family pets or service animals. Some of the findings may be applicable to other fields, such as the idea that play can positively influence the canine-handler relationship (Horvath et al., 2008), or that living with the handler instead of in a kennel also influences this bond (Lefebvre et al., 2007). However, it is difficult to measure exactly how these findings would translate to other functionalities without an experiment to determine effectiveness in these groups.

Jones and Josephs (2006) found that cortisol levels of canines that participated in a competition were sometimes influenced by testosterone levels of their handlers and sometimes not. They attributed this variability to the fact that the experiment was held in a "natural" setting, in this case directly after completing a competition, and human-canine dyads were unable to be assigned randomly. The study's results were inconclusive overall, but illustrated an important point. The winning teams did not appear to show any correlation, while the losing teams did. As discussed in the article, this creates bias because it was impossible to assign random conditions to the participants. Losing teams may have had variable testosterone levels because of stress that was not accounted for in the study. So, while it is possible to limit variables and promote good experimental protocols, bias will almost always be present in experimental reports due to factors beyond the researcher's control.

Size Matters

One of the most prevalent causes of bias in the meta-analysis was the wide variability of the number of subjects for each experiment. The largest number of subjects that a project had was 14,004 human-canine dyads (Kubinyi et al., 2009), followed by just 413 (Bennett and Rolf, 2007). The majority of experiments had less than 100 pairs of human and canine participants (eleven in this meta-analysis), which can drastically skew the data and be a significant source of bias. In the Kubinyi et al. (2009) experiment, researchers found that factors that often cause bias had a detectable but minor impact on results. While this study was performed using a questionnaire to collect data from volunteer participants, which generates bias through means described above, bias for this project was lower than many others due to the sheer number of subjects.

This is in contrast to an experiment conducted to determine whether dogs find food using exclusively human gestures or non-human tokens, an experiment which utilized only six dogs and their owners (Udell et al., 2008). The excessively small sample size made even the smallest changes significant, and affected the reliability of this study. Due to the lack of statistical power, this makes it difficult to determine trends in data. The sample size being decreased even more than originally intended is one of these influential factors. The original protocol listed eight dogs, but dropped two from the study because they were unable or unwilling to perform the procedure as intended. From a mathematical standpoint, this is significant, as each dog went from representing 12.5% of the entire sample (with eight dogs), to representing 16.7% (with six dogs). Comparably, the study with 14,004 dogs each had a representative impact of 0.7%. Essentially, the fewer the number of subjects, the greater the influence on the data and results. This "size matters"

effect also exaggerates other sources of bias that may otherwise be negligible, such as breed of the dog, age, gender, and whether or not the canine is intact.

Having larger sample sizes is not always beneficial, however. The Kubinyi et al. (2009) project had such a large sample number that it was nearly impossible to control every factor of the participants. As a result, this study included dogs of varying breeds, genders, training level, and others. The humans in the study had many different occupations and interacted with their canines differently. This is both a benefit and a drawback. Because it was an expansive questionnaire project, it would not be possible to have 14,004 human-dog dyads that are all exactly alike, and variations will occur. However, because of the breadth of the study and the large number of participants, results are applicable to a wide range of dog owners, and may be more meaningful as a result.

While smaller numbers of subjects are more common for experimental procedures, especially those with stricter parameters, this affects their study by increasing the significance of outliers and other deviations from the mean. Despite this, there are instances where large sample sizes can be susceptible to bias. It seems as though attempting to decrease bias through strict parameters may increase it in other ways, but in general, larger sample size indicates more reliable data.

Responsiveness to Social Cues

One area of human-canine interaction that appears to have been studied thoroughly is that of dogs' responsiveness to human cues, and what happens when those cues are altered and removed. Many facets of interspecies communication rely on signals between the species in question, and the presence of mind to respond to these signals. If an animal is able to interpret the message of another but chooses not to respond or adhere to these directions, a breakdown occurs and this interaction becomes ineffective. Consequently, understanding responsiveness to various social cues has become an important foundational aspect of communication, and is addressed more thoroughly than other aspects of this interaction.

Bentosela et al. (2008), Schwab and Huber (2006), and Yamamoto et al. (2009) all addressed this specific topic through experimental research. They addressed not simply the human-canine bond, but this bond in relationship to an owner-pet dynamic. By taking a situation that many owners are familiar with, such as issuing commands for a dog to "sit" or "lie down," these researchers were able to replicate similar data through multiple experiments. Canines were more likely to obey their owners when they felt that attention was focused on them (Schwab and Huber, 2006) and when they were immediately praised for their actions (Bentosela et al., 2008). This is important because it can be used by both owners' attempting to train their dogs to have manners and military dogs being trained to perform highly technical tasks.

Each of these three articles also addressed responsiveness to social cues in different situations. Bentosela et al. (2008) looked at the ability for a canine to distinguish a signal based on whether or not it provided results. It was particularly interesting

because the results showed that canines were able to learn to ignore cues from humans when it repeatedly resulted in "reward withdrawal" or frustration of the canine. The results of this study indicated that following cues is not merely a function of rote memorization in canines, but rather a combination of this and cognitive learning; determining whether or not a desired action results in reward.

Schwab and Huber (2006) and Yamamoto et al. (2009) looked at the responsiveness trait as it is affected by outside factors rather than the cognitive processes of the canine. These studies found that there are a variety of factors that influence the response to these cues, such as when they are administered (Yamamoto et al., 2009). Canines are more likely to be responsive to a command if it is issued immediately after a behavior has started to occur, as opposed to if it is delayed by even a few seconds. Similarly, Schwab and Huber (2006) found that the attentiveness of owners influenced the canine's willingness to obey commands. When the owner was looking away or left the room entirely, the dog was more likely to disobey the order to not eat the food that had been placed in front of it. Both of these experiments illustrate the importance of repeated affirmation of a command in a timely manner. This indicates some limitations of interspecies communication and addresses topics that can be more thoroughly investigated.

Social cues in humans and canines have been explored in a multitude of ways, and as a result the literature has a much larger pool of information to draw from than some other areas of interspecies communication. Despite this, it is still an area that needs attention. More experiments need to be completed in various concentrations of this subject in order to create a standard method of interpretation. Once this has been

achieved, interspecies communication and the human-canine bond can be viewed with a wider scope, opening the possibility of better experimentation and data collection.

<div align="center">Review Articles Most Comprehensive, In Depth</div>

Articles that focus not on experimental procedures, but on theoretical topics performed the best on the bias test. Review articles and meta-analyses inherently had less bias than experimental ones, because they took a closer look at why things were occurring and removed bias through discussion. While none of the articles appeared to exhibit characteristics of anthropomorphism, experimental articles were biased due to factors that are largely beyond the control of the researcher. Although bias is typically considered negative, it is nearly impossible to eliminate entirely. Part of the goal of this research was to determine whether present bias caused an article to be rendered ineffective or useless. However, some bias is acceptable, particularly if it is explored and identified in order to provide awareness of the issues of any given project. When working with live animals, it becomes difficult to control every aspect of an experiment, and this creates bias that is difficult to remove. Review articles are unique in that they can identify this bias and develop a discussion regarding it, removing it in many cases.

Elgier et al. (2009a), Hare and Tomasello (2005), and Reid (2009) all addressed the idea that dogs can communicate in a manner similar to humans, and gave reasons for this that included topics such as theory of mind, specialized learning, and social adaptations. These articles discuss the idea of responsiveness to social cues, comparing and contrasting major influences on the results that studies obtain. Additionally, they cite possible causes for the discrepancies that may occur between different studies on the

same subject. For example, Elgier et al. (2009a) stated that canines follow cues that allow them to obtain reinforcers. In other words, dogs like to listen when it results in something positive. Many pet owners are aware of this, and exploit this characteristic of canines when training them. While this has also been discovered in several other studies, such as Bentosela et al. (2008) and others described above, the Elgier et al. (2009a) study is more reliable because it collects several studies on the same subject and analyses them for correlations and common themes.

     This type of article was also much more likely to list genetics and evolution as a cause of interspecies communication than an experimental article (Hare and Tomasello, 2005; McGreevy et al., 2012; Merrett, 2015). Review articles not only mention genetics and evolution as possible theories for the underlying cause of results, they delve into detailed explanations. The same is true for psychology; where a study may mention the link between human and canine thinking in its introduction, articles that were review-based included more in depth discussions about what makes humans and canines so adept at cognitive communication (such as Merrit, 2015).

     Hare and Tomasello's article (2005) has an entire section dedicated to exploring how evolution influenced the communication between humans and canines. The article explores whether or not dogs' cognitive functions appeared as a result of evolving with humans, or merely a result of some coincidence. The first argument against the coevolution theory is that canines undergo a sort of "enculturation," or passing of knowledge between humans and canines due to their close proximity to each other during rearing. Studies are provided that show this to be false, as they used multiple ages of animals and found no correlation to their ability to understand and follow human

directives. This review article also explored the idea that canine cognition is a result of descending from wolves, and was able to disprove this through discussing another independent source.

Overall, review articles are more comprehensive and offer more in-depth answers to questions than do experimental articles. While those performing experiments have a specific question or variable they are attempting to answer, review articles have the freedom to delve into topics that are not easily consolidated into just a few lines, and provide thoughtful discussion that can lead to new innovations in the field. These types of articles often present their findings in the form of suggestions for further research, and provide a solid basis of understanding for the scientist looking to perform an experiment in this field. For the scientist who may understand the primary objective of the experiment they are designing but is looking for a broader analysis of the field of animal behavior and interspecies communication, review articles seem to be the best choice.

CONCLUSIONS

While both genetics and psychology appear to be influential factors in the development of human-canine communication, the majority of the articles presented in this meta-analysis utilized psychology because it is much more readily tested for and understood than the coevolution of humans and canines. However, both seem to be important factors in the development of interspecies communication, and should be considered when developing or discussing an experimental procedure. Review articles are better able to explore these topics because they are much broader in scope and intent than are experimental ones.

Bias, while present in many of the articles, was extremely low and did not appear to affect the validity of results. Where it did affect them, researchers almost always made an attempt to explain these discrepancies and offer solutions to remedy them in the future. Bias most often occurred because of small sample sizes and a large number of variables that are difficult to control, such as breed, age, and gender of the canines. Each dog is different, just like each person is different, and this can affect results and make it harder to gain conclusive answers. Again, review articles were inherently less biased than experimental ones because they took several studies and developed a concise theory while taking into account the benefits and limitations of each study. It appears that the early interpretations of events of anthropomorphism have passed and animals are finally being recognized for their cognitive abilities.

More research needs to be completed in order to have a more thorough base of understanding for human-canine communication and interspecies communication as a whole. A good example of this is most readily noted in the case of canines responding to

human social cues, as this area has been explored more thoroughly than others and had an expansive pool of research to draw from. However, even this area would benefit from a standardized method of experimentation that could be used on a large scale.

Finally, review articles appear to be the most thorough, least biased sources, and should be consulted first when attempting to recreate or materialize a new project in this field. However, the experimental research that is available is also of value and should not be discredited. Current research could be improved by repeating previous experiments using a larger sample size, to help eliminate sources of bias that result from having a small number of participants. Minimizing the number of variables, such as controlling the gender and age of the canines and humans involved may also assist in eliminating this bias. In general, the articles used in this study are of value and do a good job of assessing interspecies communication in humans and canines, particularly when it comes to the canines' response to human directives.

<center>Limitations of This Study</center>

There are several factors that contribute to the limitations of the study. At times, the study seems to be more of a systematic review than a meta-analysis, due to the nature of the articles used. Gathering articles with more narrowly defined parameters and performing statistical analysis on their data would put this study more firmly in the meta-analysis category. The downfall of this is that it could potentially eliminate some of the benefits of the study, as there is not a large enough pool of data to effectively analyze and come to definitive conclusions.

This study is inherently biased due to baseline characteristics and selective reporting data (Hoojimans et al., 2014). Repeating the analysis with a panel of participants rather than just one individual would assist in eliminating this selection bias and making the study more objective. Performing this study as an individual generates bias due to the subjectivity of the analysis and assigning of bias values. Another person may view bias in a particular article differently, and change the outcome as a result. Repeating the procedure with multiple individuals and averaging the results (especially when recording bias) will make the data more acceptable. This is not unlike the selection bias that occurs in many of the articles used in the study.

Another area of bias that occurs is due to the limited number of articles that were analyzed. Increasing both the number and type of articles used would expand the reach of this study, broadening the scope and allowing a more thorough investigation to be conducted. This study included only research and experimental articles, and does not mention any books or narratives (such as de Waal, 2016) that pertain to interspecies communication. While other sources of information may be considered nontraditional, they are important as they could include new information not found in the standard article. Reporting bias is also present because the study includes only studies that are published in English, and does not include those that may have been published in a language that is not native to the investigator.

IMPLICATIONS

This research, while not expanding the body of information available to the public, has improved it by analyzing what is available and determining its effectiveness. This will allow future researchers to better understand the topic of interspecies communication, making it easier for them to begin their research and to understand the common language and test methods utilized. This study also provides a format for meta-analyses and could be used as a template for research in another field. For the average person, this study may allow them to understand human-canine communication better, positively influencing their interactions with canines in the future.

REFERENCES

Bennett, P.C., Rohlf, V.I., 2007. Owner-companion dog interactions: Relationships between demographic variables, potentially problematic behaviors, training engagement and shared activities. Appl. Anim. Behav. Sci. 102, 65-84.

Bentosela, M., Barrera, G., Jakovcevic, A., Elgier, A.M., Mustaca, A.E., 2008. Effect of reinforcement, reinforcer omission and extinction on a communicative response in domestic dogs (*Canis familiaris*). Behav. Proc. 78, 464-469.

Dalibard, G.H., 2009. Parameters influencing service dogs' quality of response to commands: Retrospective study of 71 dogs. J. Vet. Behav. 4, 19-24.

Dijkers, M., 2013. Introducing GRADE: a systematic approach to rating evidence in systematic reviews and to guideline development. KT Update. 1, 1-9.

Elgier, A.M., Jakovcevic, A., Barrera, G., Mustaca, A.E., Bentosela, M., 2009a. Communication between domestic dogs (*Canis familiaris*) and humans: Dogs are good learners. Behav. Proc. 81, 402-408.

Elgier, A.M., Jakovcevic, A., Mustaca, A.E., Bentosela, M., 2009b. Learning and owner-stranger effects on interspecific communication in domestic dogs (*Canis familiaris*). Behav. Proc. 81, 44-49.

Gyori, B., Gacsi, M., Miklosi, A., 2010. Friend or foe: context dependent sensitivity to human behavior in dogs. Appl. Anim. Behav. Sci. 128, 69-77.

Handlin, L., Hydbring-Sandberg, E., Nilsson, A., Ejdeback, M., Jansson, A., Uvnas-Moberg, K., 2011. Short-term interaction between dogs and their owners: effects on oxytocin, cortisol, insulin and heart rate- an exploratory study. Anthrozoos. 24, 301-315.

Hare, B., Tomasello, M., 2005. Human-like social skills in dogs? Trends Cog. Sci. 9, 339-444.

Hare, B., Woods, V., 2013. The genius of dogs: how dogs are smarter than you think. Dutton, New York.

Hooijmans, C., Rovers, M., deVries, R., Leenaars, M., Ritskes-Hoitinga, M., Lengendam, M.W., 2014. SYRCLE's risk of bias tool for animal studies. BMC Med. Res. Methodol. 14:43.

Horvath, Z., Doka, A., Miklosi, A., 2008. Affiliative and disciplinary behavior of human handlers during play with their dog affects cortisol concentrations in opposite directions. Horm. and Behav. 54, 107-114.

Jones, A.C., Josephs, R.A., 2006. Interspecies hormonal interactions between man and the domestic dog (*Canis familiaris*). Horm. and Behav. 50, 393-400.

Kotrschal, K., Schoberl, I., Bauer, B., Thibeaut, A., Wedl, M., 2009. Dyadic relationships and operational performance of male and female owners and their male dogs. Behav. Proc. 81, 383-391.

Kubinyi, E., Turcsan, B., Miklosi, A., 2009. Dog and owner demographic characteristics and dog personality trait associations. Behav. Proc. 81, 392-401.

Lefebvre, D., Diederich, C., Delcourt, M., Giffroy, J., 2007. The quality of the relation between handler and military dogs influences efficiency and welfare of dogs. Appl. Anim. Behav. Sci. 104, 49-60.

McGreevy, P.D., Starling, M., Branson, N.J., Cobb, M.L., Calnon, D., 2012. An overview of the dog-human dyad and ethograms within it. J. Vet. Behav. 7, 103-117.

Merritt, M., 2015. Dismantling standard cognitive science: it's time the dog had its day. Biol. Philos. 30, 811-829.

Miklosi, A., Soproni, K., 2005. A comparative analysis of animals' understanding of the human pointing gesture. Anim. Cogn. 9: 81-93.

Pires, G.N., Bezerra, A.G., Tufik, S., Anderson, M.L., 2016. Effects of experimental sleep deprivation on anxiety-like behavior in animal research: Systematic review and meta-analysis. Neurosci. Biobehav. Rev. 68, 575-589.

Rehn, T., Keeling, L.J., 2016. Measuring dog-owner relationships: crossing boundaries between animal behavior and human psychology. Appl. Anim. Behav. Sci. 183, 1-9.

Reid, P. J., 2009. Adapting to the human world: Dogs' responsiveness to our social cues. Behav. Proc. 80, 325-333.

Safina, C., 2015. Beyond words: what animals think and feel. Picador Publishing, London.

Schwab, C., Huber, L., 2006. Obey or not obey? Dogs (*Canis familiaris*) behave differently in response to attentional states of their owners. J. Comp. Psych. 120, 169-175.

Spady, T., Ostrander, E.A., 2008. Canine behavioral genetics: pointing out the phenotypes and herding up the genes. Am. J. Hum. Gen. 82, 10-18.

Sriganesh, K., Shanthanna, H., Busse, J. W., 2016. A brief overview of systematic reviews and meta-analyses. Indian J. Anaesth. 60, 689-694.

Udell, M.A.R., Giglio, R.F., Wynne, C.D.L., 2008. Domestic dogs (*Canis familiaris*) use human gestures but not nunhuman tokens to find hidden food. J. Comp. Psych. 122, 84-93.

de Waal, F., 2016. Are we smart enough to know how smart animals are?, Norton, W.W. & Company, Inc., New York.

Wynne, C.D.L., Udell, M.A.R., Lord, K.A., 2008. Ontogeny's impacts on human-dog communication. J. Anim. Behav. 76, 1-4.

Yamamoto, M., Kikusui, T., Ohta, M., 2009. Influence of delayed timing of owners' actions on the behaviors of their dogs, *Canis familiaris*. J. Vet. Behav. 4, 11-18.

Zilcha-Mano, S., Mikulincer, M., Shaver, P.R., 2011. An attachment perspective on human-pet relationships: conceptualization and assessment of pet attachment orientations. J. Res. In Personal. 45, 345-357.

Table 1:
An example of some information contained in the final product of the meta-analysis.
Table is oriented horizontally and contains these columns, as well as experimental
method and notes.

Article Title	Type of Article[a]	# of Subjects	Quantitative Data	Qualitative Data	Genetics
Article 1	Narrative	N/A	No	Yes	No
Article 2	Experimental	20 (10 human, 10 canine)	Yes	No	Yes

[a] "Type of Article" refers to whether the article is experiment based, review based, or narrative based, such as in a recollection of non-experimental events. May or may not be included, depending on how the article was obtained.

Table 2:
Areas of bias, as identified by SYRCLE's risk of bias tool[a] for animal studies (Hooijmans et al., 2014).

Item	Type of Bias	Domain[b]
1	Selection Bias	Sequence generation
2	Selection Bias	Baseline characteristics
3	Selection Bias	Allocation concealment
4	Performance Bias	Random housing
5	Performance Bias	Blinding
6	Detection Bias	Random outcome assessment
7	Detection Bias	Blinding
8	Attrition Bias[c]	Incomplete outcome data
9	Reporting Bias	Selective outcome reporting
10	Other	Other sources of bias

[a]SYRCLE's risk of bias tool was developed for use in animal science studies to detect bias that commonly results from a variety of experimental areas.
[b] "Domain" represents a subcategory of bias that falls under one of five basic types: selection, performance, detection, attrition, and reporting.
[c] Attrition bias occurs when an animal or person is withdrawn from an experiment prematurely, affecting data.