<u>AN EXPLORATION OF OBJECT-WORD ACQUISITION IN CANIS FAMILIARIS</u>

by

Brianna L. Artz

A Thesis
Submitted to the
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of
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George Mason University
Fairfax, VA

An Exploration of Object-Word Acquisition in Canis familiaris

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Bachelor of Science
George Mason University, 2017

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## DEDICATION

This thesis is dedicated to my amazing grandfather, John H. Cameron.

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## ABSTRACT

AN EXPLORATION OF OBJECT-WORD ACQUISITION IN CANIS FAMILIARIS

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Language-like abilities are present across many classes of animals. Various non-human primates, the gray parrot, and dolphins have all demonstrated the ability to comprehend, and in some cases produce, spoken words, symbols or gestures representing objects or other labels (Pepperberg, 2017). It was not until recently that dogs were discovered to have the ability to understand object-word pairings through receptive language. Two border collies and a Yorkshire terrier were found to have the ability to acquire vocabularies of human words (Kaminki, Call & Fischer, 2004; Greibel & Oller, 2017; Pilley & Reid, 2011). Thus far, these two breeds are the only to be studied for their ability to understand human language. The present study seeks to better understand if the ability to understand object-word associations is present in all dogs, or if this ability might be more specific to certain breeds of dog or to certain individuals. Due to purpose-breeding, certain breeds of dog may have acquired or lost this ability over time. Seven dogs (3 beagles, 2 great Pyrenees, and 2 mixed breeds) were trained using operant and classical

conditioning to respond correctly when given the command “Find (object name)” over many training sessions. All dogs learned 25 words, but the number of sessions required before learning each to varied across dog and breed. The beagles and great Pyrenees had difficulty learning these associations at an early age, but the youngest dog (morkie, 12-weeks) never had any difficulties related to age. The oldest dog (lab/pit mix, 9 years) also had no apparent age-related difficulties. No dog in the present study learned these associations through fast-mapping like previously studied border collies. The results indicate that innate, purpose-bred behavioral tendencies may influence early object-word learning in dogs, and that the process or word learning in dogs may differ by breed. Future research on canine language learning should rely on citizen science.
*Keywords:* receptive language, dog, operant conditioning, language acquisition, canine cognition

# CHAPTER ONE

Is the ability to communicate through language what truly separates human beings from animals? This depends on what one considers language. Verbal, spoken language in the way that human beings communicate may never be achieved by a non-human animal, however, a number of animal language learning studies demonstrate that animals can develop an understanding of language-like symbolic representation (e.g. Herman & Richards, 1984; Premack & Premack 1972; Terrace, Petitto, Sanders, & Bever, 1979). Animal-language learning studies in the 1960s and 1970s tackled big questions posed by Chomsky and Skinner regarding human language learning development, and the implications were clear (Pepperberg, 2017). If Chomsky's theory that humans are gifted with a special Language Acquisition device were to be supported, the animals studied should never have developed language-like skills. But, they did. During the era of animal language learning studies, non-human primates, dolphins, and a gray parrot demonstrated that with enough training, practice, and patience, animals can develop skills comparable to human language. However, due to exciting new technological advancements in data collection methods and pressure from animal rights groups, these types of studies seemed to have fizzled out – or so we thought. (Pepperberg, 2017)

When considering which animals may have these abilities, original interest in the 1960s and 1970s naturally gravitated towards species we consider to be close in our divergent evolutionary history – non-human primates, and to grey parrots, who have the ability to produce speech. However, it was not until recently that a species experiencing thousands of years of convergent evolution through domestic pressures was found to have these skills. In 2004, *Science* published an article explaining how a border collie named Rico was found to have a vocabulary of around 200 words for objects (Kaminski et al., 2004), and later, in 2011, a study was published demonstrating that a border collie named Chaser was able to receptively understand over 1,000 names for toys (Pilley & Reid, 2011). Both dogs also seemed to have a form of inferential reasoning known as "fast-mapping," which allows for the rapid learning of new words (Kaminski et al., 2004; Pilley & Reid, 2011). One thousand words is a receptive vocabulary well beyond that of the non-human primates who had once learned language – but are all breeds of dog capable of this extensive linguistic repertoire? Is there a critical period for language learning in dogs? How do individual differences in cognitive ability relate to a dog's ability to learn object-word pairings? The present study examined these questions, attempting to gain a more thorough understanding of how dogs understand human language based on the combination of evolutionary pressures and life experience.

**Language Learning in the African Grey Parrot**

There are a number of avian species that have acquired the ability to mimic and produce sounds very similar to human language, making these animals primary subjects in the quest for understanding language comparatively. Alex the Parrot was the first subject that allowed us to truly understand the cognitive complexities of avian language production. Irene Pepperberg of Harvard University acquired Alex, a 12-13-month-old grey parrot, on June 15, 1977 and began first by training him to understand labels for objects. Pepperberg was the first to have success examining language in birds that ‘talk’ and aimed to use labeling as an avenue for testing cognitive skills that had never before been examined in bird species. (Pepperberg, 1999)

Pepperberg adopted a training strategy known as the M/R technique. This type of training involved Alex and two human trainers. However, from the perspective of Alex, one of the trainers was also a student. The human “student” would be asked questions such as “What color?” or “What’s here?” while Alex watched. Alex watched the human “student” give correct verbal responses, and watched the subsequent reinforcement attained for correct responding. In this training procedure, the human “student” served as both a model for correct behavior, and as a rival for the human trainer’s attention. This procedure was utilized throughout Alex’s life to teach him various words, and then to later test certain cognitive abilities. (Pepperberg, 1999)

After 26 months of M/R training sessions, Alex first displayed the ability to acquire and correctly use a vocabulary of English word labels including objects and colors, and even learned to tell humans “no”. Over the course of 200 initial tests of his knowledge of these words, he correctly identified 80% of objects presented. He developed the ability to not only identify different objects, but to identify items with specific *types* such as color or shape. Alex also begun to request (and even refuse!) certain objects or items available to him within this initial two-year training period. (Pepperberg, 1999)

Pepperberg went on to study various cognitive skills such as same/different identification, use of numerical concepts, object permanence, among others, using Alex's understanding of language. As demonstrated by the Alex experiments, studying these concepts in other animals requires complex behavioral methods because most non-human animals cannot communicate through vocalizations. The Alex studies demonstrated that meaningful, conversational, spoken language is not unique to human beings, and can be cultivated in other species under the right conditions. (Pepperberg, 1999) While only a select few species such as the African Grey parrot can speak human-like words due to morphological constraints, these are not the only species of interest when seeking to understand language-like abilities.

### Language Learning in Non-human Primates

When considering which other species may have the capacity to acquire language-like skills, our closest evolutionary relatives, non-human primates, were a natural species of interest. Even before language learning was the primary question, researchers have been interested in how alike or different non-human primates are from human beings. In the early 1930s, Kellogg & Kellogg (1933) raised a 7 ½ month old chimpanzee, Gua, alongside their 9-month-old son. Gua was treated as a human child rather than a pet, wearing clothes and eating typical human food. While many developmental tests were conducted, of most interest here is the comparison in language comprehension between Gua and the Kellogg's human son. At 16-months of age, Gua was able to comprehend 58 words or phrases, just behind the 68 word and phrase vocabulary of their son at 18 ½ months of age. Though Gua was immersed in spoken language and even encouraged to babble, she was never able to speak in the way humans do. Their study was the first to indicate that non-human primates could acquire receptive language abilities, and also that productive language might not be possible in non-human primates. Based on their research, future studies employed sign-language and symbols to study language use in non-human primates.

Hayes & Hayes (1951) again attempted to understand how environment could impact the development of a chimpanzee, adopting Viki a few days after her birth and raising her in their home. She was raised for three years in a manner very similar to a human child, but Viki was regularly tested and trained to improve certain abilities, something human children do not typically experience. After three years of living in their home, Viki's developmental tests revealed she was maturing similarly to that of a human child, with one major difference: language. Even with explicit training, Viki had trouble comprehending and responding appropriately to spoken words. Hayes & Hayes (1951) also made significant efforts to teach her to use verbal language, including shaping her mouth with their hands in a way more conducive to speech. Through these efforts, Viki was able to speak words that sounded similar to "mama", "papa", and "cup", and with additional training was able to correctly identify the experimenter as "mama" and "papa" and said "cup" when she wanted water. While Viki did learn to speak these three words, the major deficit in comparison to human children led the authors to assume her language abilities were more comparable to "aphasics", with difficulties in speech comprehension and production. Later investigations would reveal the deficit is not in comprehension, or even production, but chimpanzees were better equipped to express language in a different way.

Gardner and Gardner (1969) focused on implementing a sign language learning experience with a chimpanzee, Washoe. Washoe began her linguistic journey somewhere between 8 and 14 months after being captured in the wild. Washoe was raised in a lab setting but was exposed to human companionship as often as a human baby would be, creating a learning environment mimicking that of human children. Because chimpanzees readily imitate, the Gardner's utilized American Sign Language as their language-learning modality and instructed humans working with her not to speak aloud. While language-related vocalizations were not the focus of Washoe's training, she was reinforced for attempts at babbling. After 22 months of daily, immersive learning, Washoe could effectively communicate using 30 signs to gain things she wanted in her environment and could even combine them to create short sentences. By age 4, Washoe had developed a vocabulary of 125 words (Hixson, 1998). Human children typically have a vocabulary of 100-2,000 words by the second or third year of life, in comparison (Berger, 2014).

The sign language learning capacities of chimpanzees were again explored with a chimpanzee, Nim, who was exposed to language in an entirely immersed way – while living in a human home environment. The researchers intended to further explore the capacity for chimpanzees to sign a syntactically meaningful sentence. They found that Nim was able to create seemingly rule-governed, meaningful patterns of signs, and that the order of these signs was typically consistent. For example, *more + X* was more commonly used than *X + more*. However, when Nim began signing three and four sign sentences, the content was often not much different than if Nim had used only two signs. For example, the most common three-word utterance “play me Nim” expresses the same idea as “play me” or “play Nim”. The same pattern of utilization was found in four-word sentences, with the most common being “eat drink eat drink”, an expression that could have been sufficiently expressed using two signs. When human children begin using longer sentences, the added words are semantically meaningful and add more context and detail to the statement. Nim, on the other hand, increased the number of signs used, but this increase did not typically reflect a semantic difference. While Nim developed a meaningful system of communication between himself and experimenters, his semantic and syntactic usage of this communication system differed from the way a human child would utilize it. (Terrace, Petitto, Sanders, & Bever, 1979)

Premack & Premack (1972) created an inter-species communication system using symbols rather than spoken or human language. The authors argued, “to a large extent teaching language to an animal is simply mapping out the conceptual structures the animal already possesses.” (p. 95). Chimpanzees already have conceptual structures understanding symbols of differing shapes, sizes and colors to understand which foods to consume in the wild. Premack & Premack (1972) capitalized on this, creating a symbolic language system where symbols represent objects and concepts, rather than words or hand signs. Sarah was able to understand symbolic representations as full sentences (see *figure 3* for an example), exemplified by her ability to understand commands communicated through the symbols. This study opened the door for using strategies other than traditional human forms of communication in animal language-learning studies, especially for species with difficulties producing vocal or signed speech.

Chimpanzees have been found to learn sign-language and symbolic languages but have exhibited some difficulty in learning spoken words when presented alone without gestural cues. Savage-Rumbaugh et al. (1986) explored language learning in the pygmy chimpanzee and found that this difficulty in learning spoken words was absent. Two pygmy chimpanzees or bonobos, Kanzi and Mulika, exhibited what the authors described as comprehending spoken language “spontaneously”. That is, without any formal training or food reward system in place. This is something that common chimpanzees had been exposed to in the past, but additional training was added because they would not learn observationally (e.g. Hayes & Hayes, 1951). Kanzi and Mulika learned symbol-object associations where human speech was associated with symbolic lexigrams on a keyboard. The bonobos also began using sentences representing *agent-verb-recipient,* where they would refer to situations that didn’t include themselves, a behavior not demonstrated by the common chimpanzee. Bonobos may have an enhanced communication system due to their roles in their social groups. Common chimpanzees are more aggressive and less cooperative between and amongst the sexes when compared to pygmy chimpanzees, with the latter settling conflicts in a more egalitarian way (Boesch, Hohmann & Marchant, 2002). This difference in societal structure may have better primed the pygmy chimpanzee for comprehending and using human language.

Considering a different non-human primate, Patterson (1978) evaluated a gorilla, Koko, on her ability to utilize American Sign Language while being immersed in both spoken and signed English. In order for the experimenters to consider a word learned by Koko, she would have to use it appropriately and spontaneously at least 15 days per month. Similarly to Washoe, Koko acquired the ability to communicate using nouns, pronouns, modifiers, verbs, prepositions, and even negatives in order to communicate with experimenters to gain things she desired. Throughout her life, Koko continued to add words to her vocabulary and increase her word use, effectively having seemingly regular conversations with human beings. While her language abilities continued to increase with age, they never reached the level of human syntactic and semantic sophistication.

**Language Learning in Bottlenosed Dolphins**

Bottlenosed dolphins do not have hands and vocalize in the form of whistles much different from human speech sounds. However, they have demonstrated a complex intraspecies communication system related to mating, playing and foraging, and whistling increases in instances of communication during cooperative tasks (Eskelinen, Winship, Jones, Ames, & Kuczaj, 2016). Whereas dolphins cannot produce speech in the way humans can, Herman & Richards (1984) found that dolphins can develop an understanding of comprehensive language-like abilities.

Two bottlenosed dolphins, Phoenix and Akeakamai, demonstrated the ability to comprehend full sentences through specialized “languages”. Although the dolphins never learned words in the traditional sense, Phoenix learned an acoustic-based language played through underwater speakers, and Akeakamai learned a visually-based language reliant on arm and hand gestures displayed by a trainer. Similarly to spoken or signed human language, the words could be recombined into unique sentences with hundreds of different meanings. The dolphins were able to understand two-five word sentences at above chance levels, responding accurately to commands and instructions given to them in their unique language. The dolphins demonstrated an understanding of the meaning of each word, whether representing an action, modifier, object or person. Akeakamai and Phoenix demonstrated the ability to understand semantically, structurally, and lexically novel sentences, as well as conjoined sentences, and sentences where the position of a modifier changed the meaning of a sentence. (Herman & Richards, 1984)

Dolphins have exhibited the ability to understand complex hierarchical language associations in both acoustic and gestural formats. While their comprehensive abilities would likely generalize to human-like communication in the form of words, it has yet to be investigated.

**Language Learning in Dogs**

Dogs, like bottlenosed dolphins, do not have the morphology required to produce human language in the way that people do. However, anecdotal evidence from dog owners suggests that man's best friend seems to understand words for things like "outside" or "dinner", suggesting a degree of language comprehension. In 2004, these anecdotes entered the realm of experimental science when a border collie named Rico came to the attention of Kaminski, Call, & Fischer (2004) due to his supposed understanding of ~200 human words. Rico was first introduced to learning the names of objects around 10 months old when his owners began playing fetch with him using different items, all with unique names. Researchers were skeptical of his reported ability, assuming the "Clever Hans" effect (Pfungst, 1998). The "Clever Hans" effect occurs when an animal seemingly exhibits certain cognitive skills, but instead their behavior is representative of their ability to read subtle, unconscious body language cues of the trainer. However, when tested using toys retrieved from another room, Rico retrieved 37/40 toys correctly (binomial test, $p < 0.001$), refuting the possibility of the Clever Hans effect. In addition to testing his knowledge of words learned at home, researchers tested Rico's ability to learn the names of new toys through fast-mapping. Rico was able to correctly identify 7/10 new objects using only exclusionary logic, no training, and could still recall 3/6 of these fast-mapped words 4-months later. This recall ability is on par with 3-year-old human children. The fun game Rico's owners created to stimulate their high energy border collie stunned researchers and laypeople alike, sparking interest into how dogs comprehend human language.

Following Rico's comprehension after relaxed, at-home games, Pilley & Reid (2011) decided to take a more intense, immersive approach to comprehensive language training with another border collie, Chaser. Beginning at 8-weeks of age, Chaser experienced 4-5 hour training sessions each day, learning the names of roughly 1-2 words per day. Over a three-year period, Chaser learned the names of over 1,000 toys. Chaser also demonstrated knowledge of the difference between nouns and commands, distinguishing between names of objects, and names for different commands (touching an item with her paw or nose, or fetching the item) simultaneously, responding correctly 14/14 times during test trials. Like Rico, Chaser also demonstrated the ability to learn words through exclusionary logic, but only after repeated suggestions and encouragement. (Pilley & Reid, 2011) At age 7, Chaser's ability to understand syntax was explored using English words arranged in a sentence structure found in the Spanish language (for example, "to ball take Frisbee" rather than "take Frisbee to ball"). Using this syntactic pattern, Chaser was able to correctly perform 25/32 ($p < 0.001$) full sentence commands. This same protocol was conducted, only with one of the toys being a novel toy. Results suggest that even in a more complex sentence structure, Chaser could usually correctly perform the commands through inferential reasoning (75% accuracy). (Pilley, 2013)

Border collies were specifically bred to herd alongside shepherds in the rocky highlands of Wales and Scotland (Coile, 2015). Understanding both verbal and nonverbal commands from the shepherd was imperative for successful herding, so dogs exceling at this receptive communication were selected more often for breeding. Over time, purpose-breeding has created a breed described as intelligent, athletic and trainable, a breed that is happiest when working or active in activities such as agility (Coile, 2015). Due to these breed characteristics, border collies certainly seem ideal for demonstrating a dog's ability to understand human language. While Chaser and Rico both demonstrated an amazing linguistic understanding, this might be due to their breed, rather than their overall species distinction of "dog". Are border collies special or can all dogs learn 1,000 words?

Greibel & Oller (2017) discovered that acquiring a large vocabulary of human words for items was not something unique to the border collie breed. Bailey, a 12-year-old female Yorkshire terrier spent her life learning the names of toys in the relaxed environment of her own home before being tested by researchers. Bailey had learned the names of ~120 toys over the course of her 12-year life through informal training by her owner. When her owner purchased a new toy for her, it was introduced to her by name several times. She had the opportunity to play with it, and then it would eventually be placed in the pile with all the other toys available to Bailey, where she would then be asked to fetch the object by name. Bailey's ability to remember toy names was tested empirically with the voice of her owner, and she missed only 5 of a total 97 trials ($p < 0.0001$). Bailey's ability was also tested with unfamiliar voices, yielding again a high degree of retrieval accuracy ($p < 0.0001$). Like Rico, Bailey was tested on her ability to learn new toys based on exclusionary knowledge, or fast-mapping. While Rico demonstrated the ability to use inferential reasoning to determine the novel toy name, Bailey had more trouble with this. Out of 10 sets of toys (6 old, 1 novel), Bailey only correctly identified two of the 10 new items by exclusionary knowledge. Bailey demonstrated that lap dogs can acquire large vocabularies for human words, but that fast-mapping was not the skill she used to acquire them. Bailey's understanding can be better described as operant learning, where she gradually learned word-object associations after reinforcement from her owner.

Thus far, Rico, Chaser and Bailey have been the only three dogs tested for the ability to learn object-word pairings. In order to gain a better understanding of how purpose-breeding affects the understanding of human language in dogs, more breed-groups must be included in comparative designs of language acquisition in dogs.

## The Present Study

The present study investigated unanswered questions about how purpose-breeding might affect a dog's ability to acquire object-word pairings. Thus far, other studies have examined border collies (herding group) and a Yorkshire terrier (toy group), finding that both breeds can achieve an extensive repertoire of names for toys. Border collies have demonstrated the ability to fast-map, whereas the Yorkshire terrier did not. The present study included three beagles (hound group), two great Pyrenees (working group), one Labrador Retriever/Pitbull mix (sporting group), and one Yorkshire terrier/Maltese mix (toy group), expanding the number of breed-groups investigated.

Another factor of interest is the age of the dog when object-word pairings are introduced. In humans, there is a critical period for language learning (Berger, 2014) – is there a critical period for dog language acquisition? Our subjects began training across several different ages. The beagles began training at 6-months of age, the great Pyrenees began training at 3-years-5-months of age, the lab/pit mix began training at 8-years-11-months of age, and the Yorkshire terrier/Maltese mix began training at 3-months of age. Perhaps of the most interest, the great Pyrenees were involved in a similar study beginning at their 6-month mark, but they did not learn a single word. Comparing results to their progress in the present study will potentially elucidate factors influencing the interaction of purpose-breeding and life experience.

A secondary goal of this research was to find a protocol that might be suitable for replicability by citizen scientists with their own companion dogs. The subject number recruited for this study is not large enough for a detailed statistical analysis of breed or age interactions but can inform larger scale future studies conducted by citizen scientists.

It was hypothesized that 1) breeds purpose-bred to work or live alongside humans would acquire words more quickly than those bred to work and make decisions alone, 2) learning trends would be similar across breeds (can only measure with beagles and great Pyrenees), and 3) age may hinder the ability to learn language at all, or slow down acquisition.

# CHAPTER TWO

## Methodology

### Participants

Participant dogs (N = 7) included beagles (N = 3, 2 female), great Pyrenees (N = 2, female) a Labrador retriever/pitbull terrier mix (female), and a maltese/yorkie mix (male). The dogs lived as companion animals in homes local to George Mason University. Dog owners allowed their dogs to participate in research and the protocol was approved by the IACUC of George Mason University. At the beginning of the study, the beagles were 6-months, the great Pyrenees were 3-years-5-months, the pitbull/lab mix was 8-years-11-months, and the maltese/yorkie mix was 3-months. All three beagles came from the same litter, and the two great Pyrenees are from the same litter as well. Both great Pyrenees, one beagle, and the lab/pitbull mix sat in the presence of food due to minimal training, but no further training was provided aside from the discrimination protocol described below. The great Pyrenees were included in a study with similar methodologies beginning at 6-months of age, but the training sessions were unsuccessful and neither dog learned any words.

### Materials

A Macbook with Microsoft Excel and SPSS was used to store and analyze data. An iPhone 8 was used to record time and treats were used as reinforcers during training sessions.  Common dog toys purchased from local stores were used as referential objects during discrimination training. These toys were varied in size, color and appearance.

## Procedure

### *Object Discrimination*

The seven dogs participated in a protocol with trainings ranging from twice per week, to once per month dependent on the availability of dog owners. The same experimenter worked with each dog during all training sessions. All dogs were trained for 15-minutes per session unless the learning threshold was met before the 15-minutes ended.  Because the intervals between training sessions were not always equal, latency was measured in the number of training sessions rather than the amount of time passed. The first few sessions began outdoors, then remaining sessions were moved into a temperature-controlled garage. Dogs were given the opportunity to adjust to surroundings for as long as needed each session before beginning formal training and time-recording to account for any attentional differences resulting in any changes to the experimental setting.

At the start of each session, dog toy(s) were placed on the ground in the training area. The number of toys placed on the floor was dependent on the stage of training the dog had reached, but the total number of toys available at one time did not exceed five. Once the dogs had reached the learning threshold for five toys, older toys were cycled through sessions randomly to ensure retention. Dogs were instructed to “Find (object name)” in a randomized order throughout training sessions. The trainer shaped behavioral indicators that were natural to the dogs based on morphology. For the great Pyrenees, putting their paw on the correct toy was shaped. For all other dogs, touching their nose to the correct toy was shaped. Two distinct toy-trainer formations were utilized to maximize the number of rewarded trials and optimize learning potential in different stages of learning (See *Fig. 1 & Fig. 2* for diagrams).

As new toys were added, the toy-trainer formation depicted in *Figure 2* was utilized. With the trainer so close, distal and proximal pointing was used to encourage joint attention and to facilitate learning. This technique allows for scaffolding to occur, where the dogs are still making independent choices to respond to known objects but are given referential assistance when needed with novel toys. As the dogs began to respond to the new toy with more accuracy, the toy-trainer formation was shifted to that of *Figure 1*. Dogs were then given the vocal command and were expected to accurately respond in the absence of any gestural cues. Once in this toy-trainer formation, dogs were eligible to test into the next toy learning phase. If in this formation, the trainer would periodically "test" the dogs – that is, record the number of correct responses out of 10. The experimenter asked the dogs to find each available object twice in a randomized order to ensure that each toy was tested twice before passing. If the dog responded correctly at least 8/10 times, they were considered to have passed that toy-learning criteria, and a novel toy was be added at the beginning of the subsequent training session. The dog would only be eligible for passing if the 2/10 missed responses were not identifying the novel toy. If the dogs met the learning criteria for the novel toy phase, they also correctly identified older toys that had been reincorporated at random. This method required that the dogs demonstrate their knowledge of both old and new toys in order to progress, a requirement that was never placed on Chaser, Rico or Bailey.

During object discrimination training, dogs were rewarded with treats and a secondary reinforcer of either “Good girl/boy” to indicate correct responses or hear an aversive “*Ehhhh”* sound vocalized to indicate incorrect responses. Training concluded once the dogs learned a total of 25 words due to the length of the study.

*Test of Fast-Mapping*

As the dogs progressed through training stages and new toys were added, inferential reasoning or “fast-mapping” was tested in a way similar to Pilley & Reid (2011). On every fifth toy learned, it was introduced not as described above, but by simply placing it in the formation order as seen in *Figure 1.* At this point, the experimenter would command, “Find ‘novel toy name’, with no gestural aid or further indicators of which toy she is referring to. This was repeated 8-times, with the correct number of responses recorded. During this time, correct responses were not rewarded. After the brief test of fast-mapping, the experimenter attempted to integrate the new toy in with the others without any further joint attention aid. If the dog struggled to integrate the new toy, or to understand the object-word pairing, the protocol returned to what is described above.

# CHAPTER THREE

## Results

Line graphs were plotted to represent the number of sessions required before reaching threshold for toy learning (*Figures 4-12).*

### *Beagles*

All three beagles required 8 or more training sessions to learn their first two object-word pairings. Importantly, after the first word pairing, the beagles attempted to learn a second toy for 10 sessions without success before replacing it with a new toy with a new name. The first toy name, “Squishy”, may have been too similar to the original second toy, “Petrie” for the dogs to discriminate. This failed toy-learning is not represented on the graph. The second toy depicted on the graph was “Star”, an object-word pairing the dogs successfully acquired. Beginning with the third toy learned, the beagles required between 1-5 sessions to reach the new toy’s learning threshold. As depicted in *Figure 11*, all three beagles followed a similar learning trend.

Individual differences were demonstrated amongst the three beagles. After the first three toys, Daisy demonstrated the least amount of variability in the number of training sessions required. Only one toy required four sessions, while all other learning thresholds were met in one or two sessions. Henry and Penny Lou showed more variability in the sessions required to reach threshold, with Penny Lou varying between 1-

5 and Henry varying between 1-4 required sessions. The individual variability seen here is likely due to differences in temperament.

***Great Pyrenees***

Both great Pyrenees participated in a similar prior study but failed to meet the learning criteria for any object-word associations. Interestingly, in the present study 3-years later, the dogs demonstrated the ability to learn these pairings. As depicted in *Figures 7 & 8*, both dogs learned their first few object-word pairings in under 2 sessions, with the rest of the words learned requiring between 1-5 training sessions. The learning curves for both dogs together (*Figure 12)* demonstrated rapid learning initially, then increased variability in the number of sessions required as the number of toys learned grew.

***Labrador retriever / Pitbull mix***

Beginning our study at almost 9-years of age, Blissy had no trouble learning her first object-word pairing in only one session (Figure 9). After learning the first pairing, Blissy required between 1-5 sessions to acquire the remaining object-word pairings. Her data trends are visually similar to that of the great Pyrenees, depicted in Figure 12.

***Maltese / Yorkshire terrier mix***

Despite his young age of 12-weeks, Frank only needed one session to reach the learning threshold for his first object-word pairing. Throughout the study, Frank only required 1-2 training sessions to reach the learning threshold for each word.

### ***Fast-Mapping***

The fast-mapping trials for all dogs were inconsistent across trials (see *Figure 14*). The total percentage of correct responses during fast-mapping trials did not exceed 50% for any dog. The inconsistency in responding during these trials indicates that no dog consistently identified the novel toy's name through inferential reasoning or fast-mapping.

# CHAPTER FOUR

## Discussion

The present study demonstrates that the capacity to learn object-word pairings likely generalizes to many types of dogs, but that the speed and process of learning differs dependent on individual or group-level factors. All dogs successfully learned 25-words, and the rate of learning suggests that with continued training the dogs would likely have continued to acquire new object-word pairings. The results are not suggestive that dogs have the ability to comprehend or communicate using human language in the way human beings do. But, are suggestive that dogs can use spoken words alone as an effective stimulus for a specific behavior targeted at a specific object (referential language). Understanding this receptive form of interspecies communication is important for managing dogs living as companion animals in private homes as well as dogs who fulfill a more working or service role for handlers. While dogs throughout history have served purposes ranging from herders to livestock guardians, many of these same dogs are now living in private homes or serving in different working roles. For example, rather than fulfilling their purpose-bred duties, many dogs are providing effective services to veterans with PTSD ranging from medication reminders to mobility assistance (O'Haire & Rodriguez, 2018). The companion dogs of "today" may have been artificially selected for specific purposes, but typically serve much different roles. The results from this study indicate that the intersection between a dog's purpose-breeding and life experience may influence how quickly the dog can learn receptive language-like skills.

### *Fast-Mapping*

In past studies, Rico and Chaser (border collies) were able to use inferential reasoning to correctly identify toys they never had formal training with. However, Bailey (Yorkshire terrier) was unsuccessful at fast-mapping despite acquiring a vocabulary of ~100 words during at-home training sessions. The dogs included in the present study also failed to demonstrate an affinity for fast-mapping but were able to learn object-word pairings after repeated training sessions.

While more data should be collected on border collies compared to other breeds before drawing further conclusions, the mechanisms underlying object-word associations may be very different for border collies. Of the ten dogs studied for their understanding of object-word pairings, only the two border collies demonstrated the ability to use fast-mapping to learn new names for toys. When considering purpose-breeding, not all dogs were selected for their ability to understand and respond to specific verbal or non-verbal cues, but border collies were (Coile, 2015). This artificial selection for human attentiveness and responsiveness to vocal commands may have afforded the border collie breed unique inferential reasoning capacities similar to what is seen in human fast-mapping, as demonstrated by Rico and Chaser (Kaminski et al, 2007; Pilley & Reid, 2011).

### *Age-related Factors*

Prior investigations into canine language-learning included two dogs who had been trained at home since a young age, and one dog who began a formal training program with researchers from 8-weeks of age (Kaminski et al, 2007; Pilley & Reid, 2011; Griebel & Oller, 2012). For this reason, our senior participant Blissy was included in this study to determine if a critical period exists for understanding object-word associations, as the critical period for language learning exists in humans (Berger, 2014). Blissy required between 1-5 trials, matching the beagles and great Pyrenees in latency range, and acquired her first object-word pairing in a single training session. Blissy's older age did not prevent her from acquiring an understanding of object-word associations.

While older age did not prevent learning, results suggest that certain dogs may not be receptive to learning object-word pairings until a later age due to individual or breed-based differences. A discussion of breed-related factors possibly influencing this delay in acquisition are described below.

*Breed-related Factors*

The breeds of most interest in this study are the beagle and great Pyrenees because their purpose-bred roles were much different than those of border collies or Yorkshire terriers. The great Pyrenees was bred to work as livestock guardians and protectors, solving problems based on independent decision making. In this role, they were required to make independent decisions rather than following detailed commands. For the great Pyrenees, understanding and responding accurately to human commands would not have provided any advantage to their work (Coile, 2015). Similarly, beagles were bred to work as pack-hounds hunting rabbits, their decisions based on information gathered through scent rather than by verbal or non-verbal commands (Coile, 2015). Importantly, it was these two breeds of dog who experienced learning difficulties when beginning to associate the object-word pairings.

While both the beagles and great Pyrenees displayed difficulty responding correctly beginning around 6-months of age, the reasons for their lack of performance differed. Frongello (2015) described that even with treats as reinforcers, it was difficult to motivate the dogs to participate in trainings. The great Pyrenees would spend large portions of training sessions lying down and resting rather than participating, matching their breed's tendency towards stubbornness and inactivity. The behavior of the beagles during training sessions also hindered their concentration on the training task. The beagles would often be distracted by unrelated smells or items in the testing area, or simply become too excited to emit meaningful responses. It seemed that during initial training at the young age of 6-months, both breeds had trouble abandoning breed-specific behaviors that would hinder acquisition.

The results suggest that after some time, the learning trend began to shift for both breeds of dog. For the beagles, this is represented by the reduction of required sessions before passing at toy 3. At this point, the behavior of the dogs changed in a way that was more receptive to learning the pairings. Rather than attending to various smells, the beagles began to attend more to the verbal and non-verbal cues of the experimenter. This shift in attention and motivation is something that was not described by Rico or Bailey's owners and was not demonstrated in the Chaser studies.

A similar attentional and motivational shift can be assumed in the case of the great Pyrenees. Their initial training ended around 9-months, and when it was continued at 3-years-4-months the differences were dramatic. The great Pyrenees were very receptive to the gestural cues of the experimenter and acquired their first object-word pairings in two or less sessions. While the great Pyrenees did spend time laying down and resting during some sessions, it typically did not last very long. The experimenter was usually able to encourage participation through joint attention and rewards.

Because the initial training of the great Pyrenees was terminated, the exact timing of the behavioral changes cannot be known. The beagles demonstrated a shift in attention at the third toy learned, which occurred ~9 months of age. If initial training had continued, the great Pyrenees may have shown a similar learning trend. The change in the rate of learning may be due to a shift from behaviors indicative of the breed's purpose to behaviors that the dog has learned will earn social or food rewards. For dogs purpose-bred to be attentive and affectionate to their owners, such as toy breeds ("The 7", 2009), this attention toward a human handler or trainer may be more innate.

Griebel & Oller (2013) did not report that Bailey had any difficulties learning these associations from a young age, or that she got better with age. Frank, a toy-breed mix similarly did not show the same behavioral hinderances that were demonstrated by the beagles and great Pyrenees. He was immediately receptive and responsive to the training and readily used gestural cues to understand the object-word associations, and ultimately to earn treats and social reward. It is possible that for Frank and other toy dogs, their instinctive behaviors are better suited for acquiring object-word associations through operant conditioning.

*Limitations*

The main limitation in this study was the number of dogs included, as a larger sample size would provide a more conclusive outlook on how breed or age influence capacity for object-word learning. However, given this limitation, the present study includes 7x the number of dogs included in the three prior investigations, providing important insight into the generalizability of this ability.

While the present study did include different breed-groups, the ages between these breed-groups were different. This limits the ability to draw definitive conclusions between breeds. With dogs of different breeds and ages, it is hard to decipher which factors truly influenced the dog's behavior. While more research is necessary before determining the true intersection of breed and age, this study elucidates the need for said research.

The amount of training and gaps between training may also be considered a limitation when compared to Chaser's intensive, daily training regime. Certainly, if the dogs had been trained for 5-hours a day, they may have acquired larger vocabularies. However, an intensive daily training program is likely very different from how dogs in private homes learn or begin to understand spoken language. Additionally, the latency of learning is better elucidated with an extended training paradigm.

*Future Directions*

Future investigations into object-word learning in domestic dogs should focus on dogs living as companion animals, rather than dogs housed in a laboratory or research center. Given that life experience may be an important influence on this type of learning, changing the natural environment of the domestic dog to a lab setting may render any results ungeneralizable. In order to study a large sample of dogs simultaneously, current trends in citizen science should be utilized to collect data with the help of dog owners.

Stewart et al. (2015) analyzed citizen-science data from the website Dognition.com to determine if data collected by 500 dog owners through at-home tests replicated results previously found in lab-based canine cognition studies. Most of the cognitive tests given to dogs by their owners replicated findings from previous lab-based studies and a prior Beta test, suggesting that the methods and collection procedures followed by dog owners were sound.

Requesting a team of researchers to simultaneously train hundreds of dogs would not be feasible, but perhaps requesting the help of hundreds of trained citizen scientists could be. Through the use of online recruitments and trainings, the present study could easily be replicated using dog owners as trainers and data collectors. Utilizing citizen science techniques, data from dogs of varying breed and age could be collected to look for differences in the speed or asymptote of learning. With citizens serving as scientists, trainings their dogs and recording data, information could be gathered much more quickly. If enough data were accumulated, breed-group or even specific breeds could be compared to one another to better understand how purpose-breeding might affect the ability to learn these associations.

**APPENDIX**

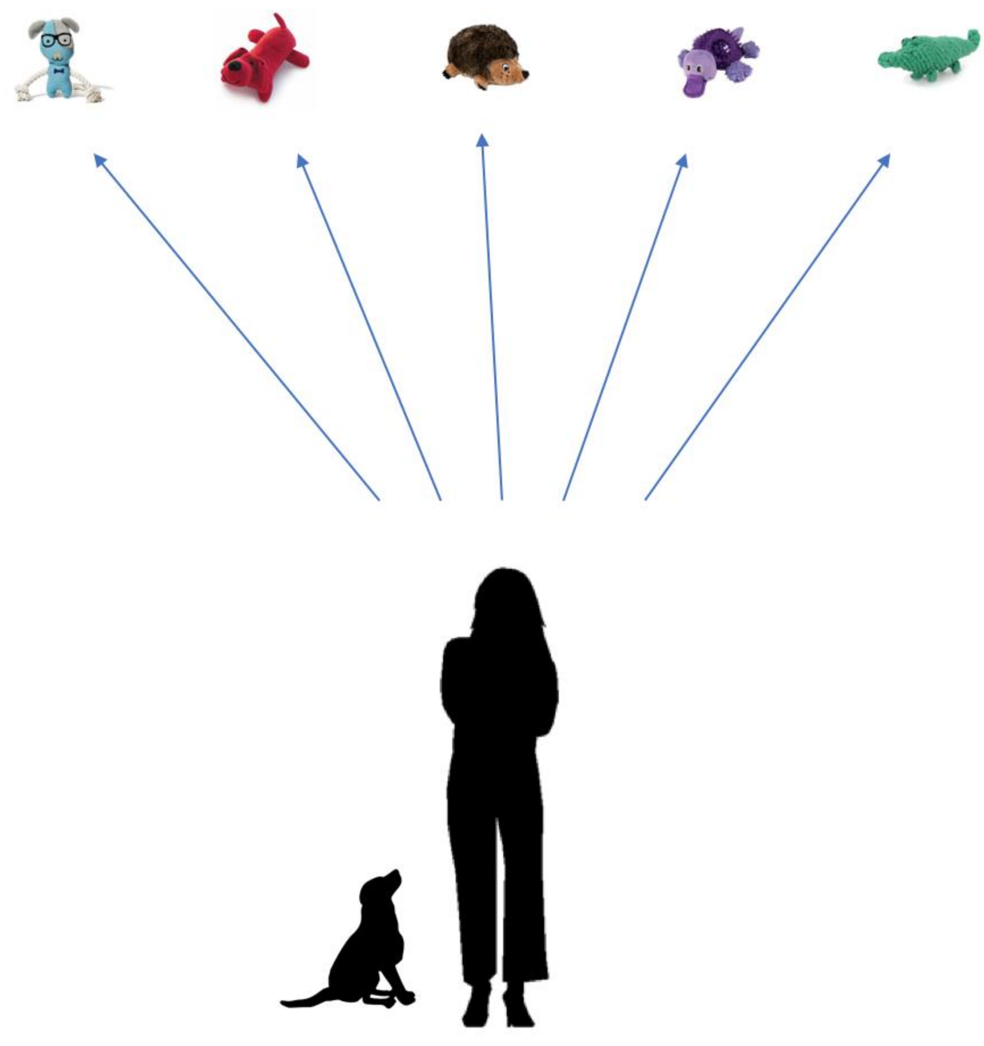

*Figure 1:* This figure depicts the toy-trainer formation that was used for phase testing, and training just prior to phase testing. The toys are placed approximately 1-foot apart, while the trainer stands approximately 10-feel away. This toy-trainer placement will be used for 1-5 toys. Arrows represent examples of certain paths dogs took to reach the toy.

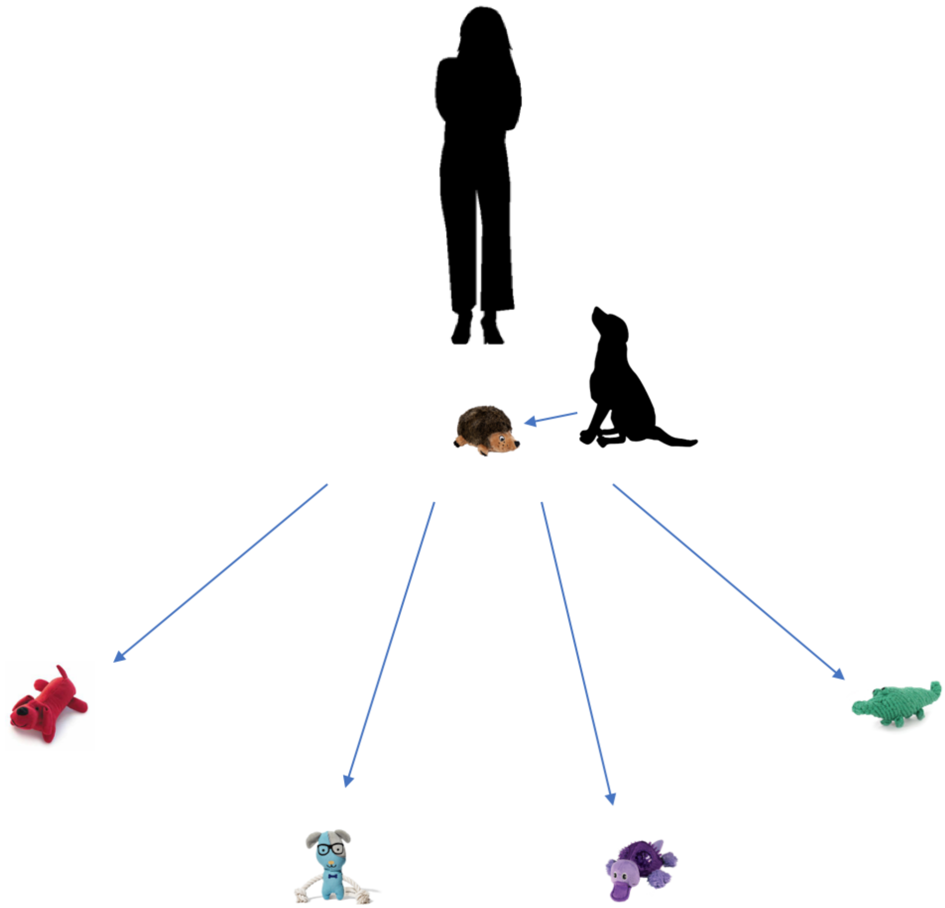

*Figure 2*: This figure depicts the toy-trainer formation when new toys were introduced. The new toy was placed approximately 1-foot away from the trainer, while all other toys were placed approximately 10-feet from the trainer, 1-foot away from each other. This toy-trainer placement was used for 1-5 toys. Arrows represent examples of certain paths dogs took to reach the toy.

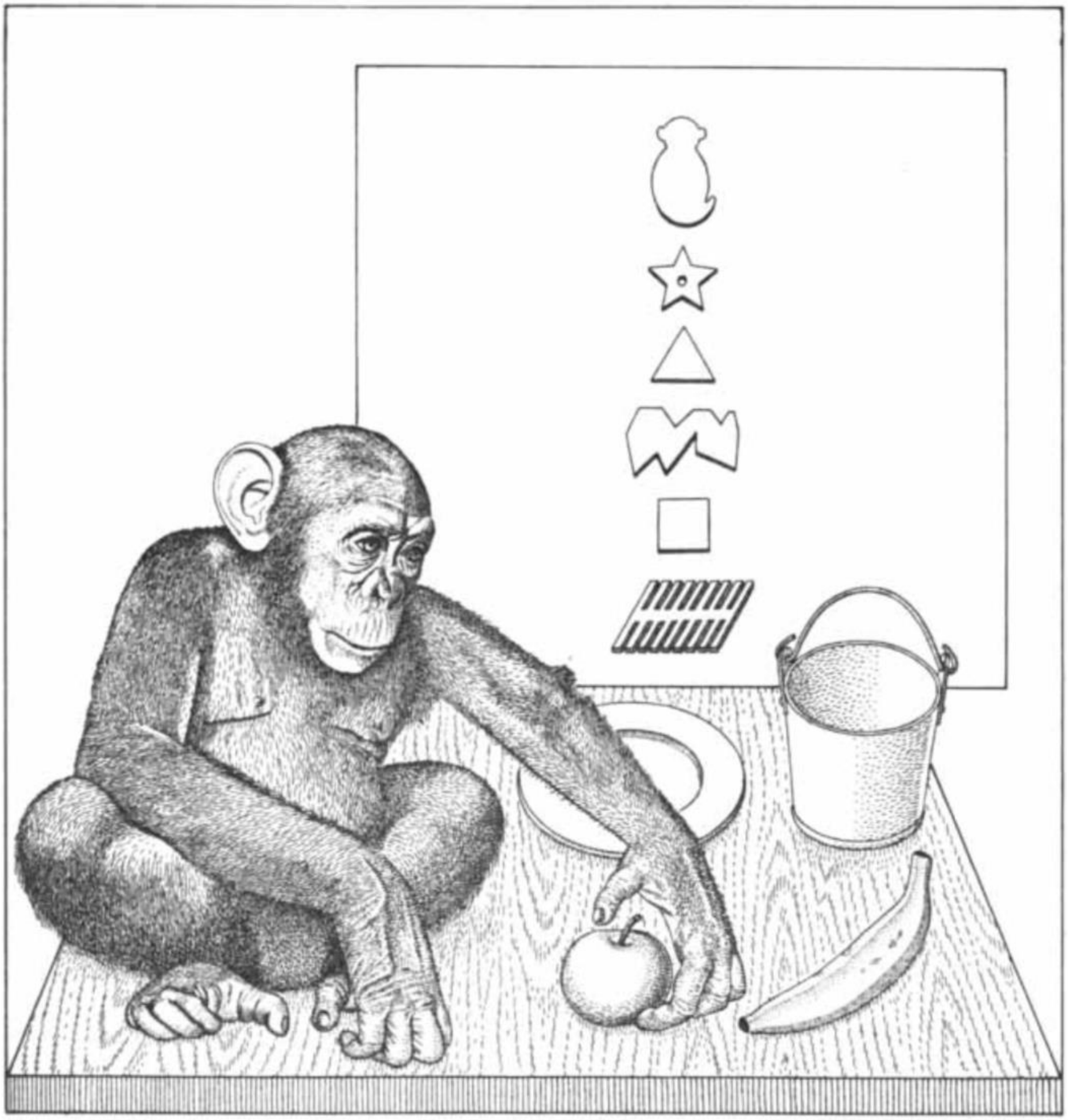

*Figure 3:* A depiction of Sarah the Chimpanzee reading the message "Sarah insert apple pail banana dish" on a board and performing the appropriate command. (Premack & Premack, 1972)

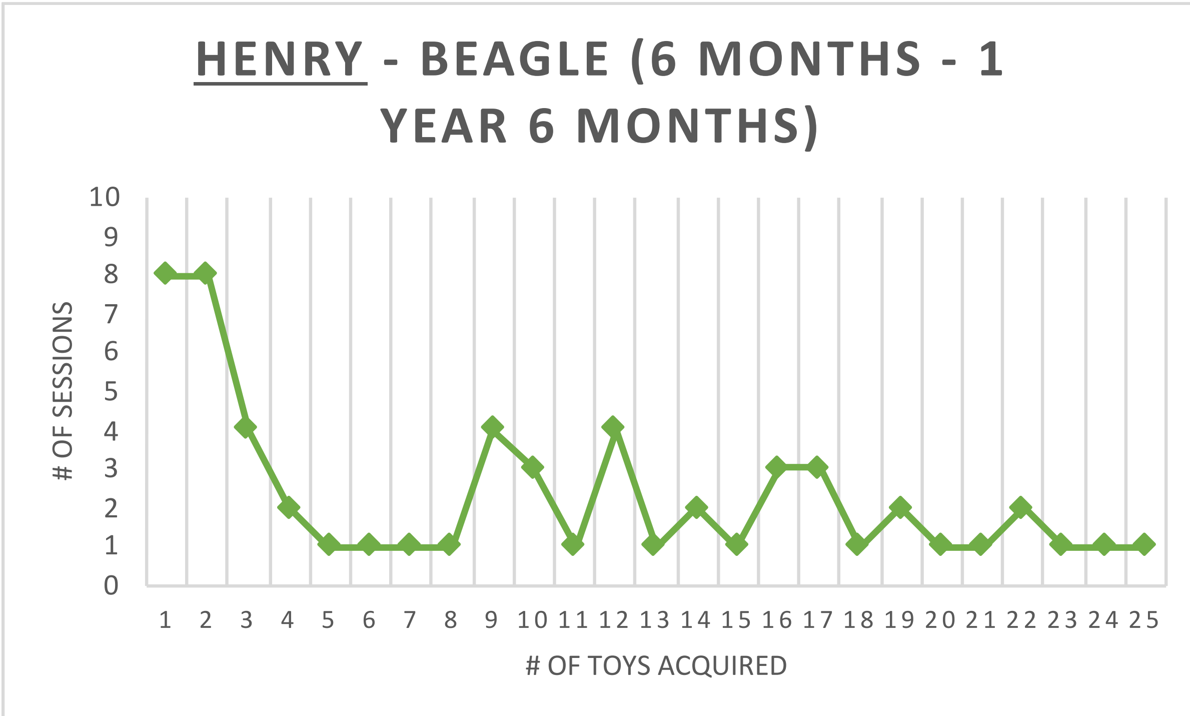


*Figure 4:* Acquisition data for Henry (beagle, male). X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

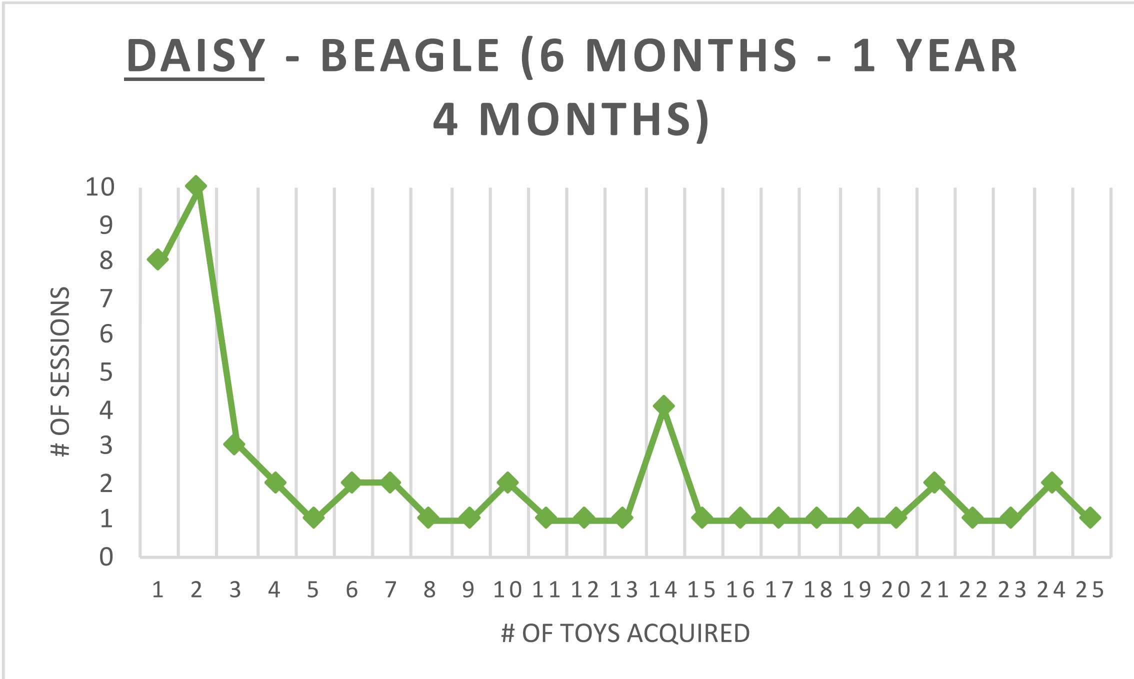


*Figure 5:* Acquisition data for Daisy (beagle, female). X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

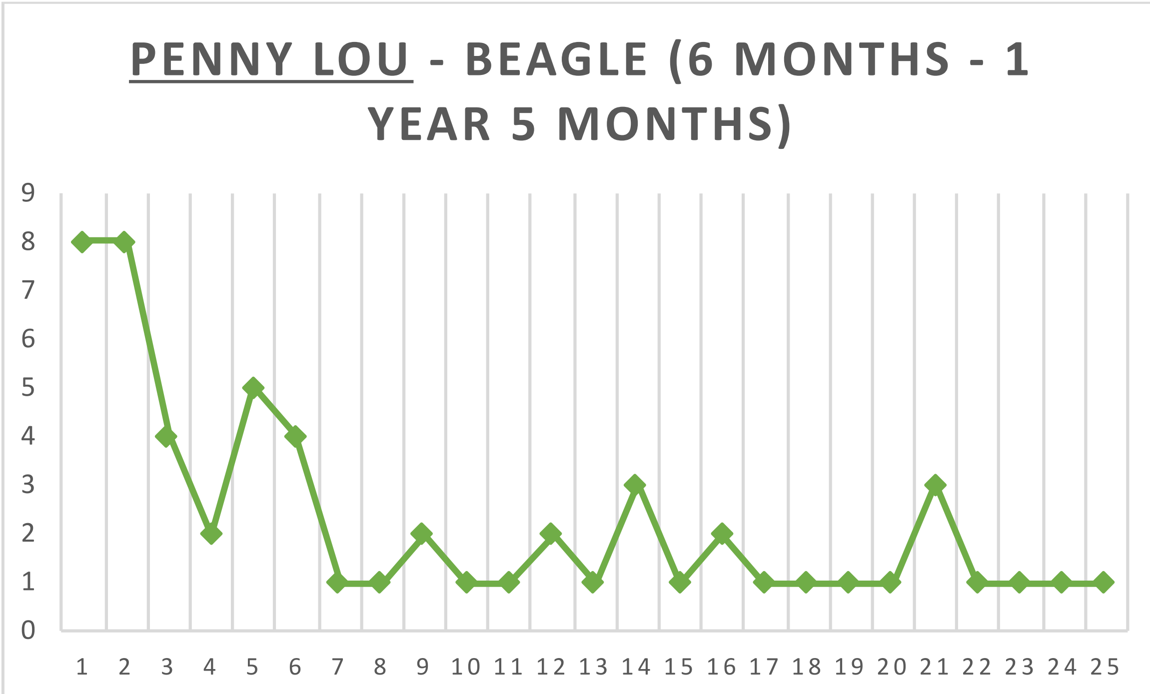


*Figure 6:* Acquisition data for Penny Lou (beagle, female). X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

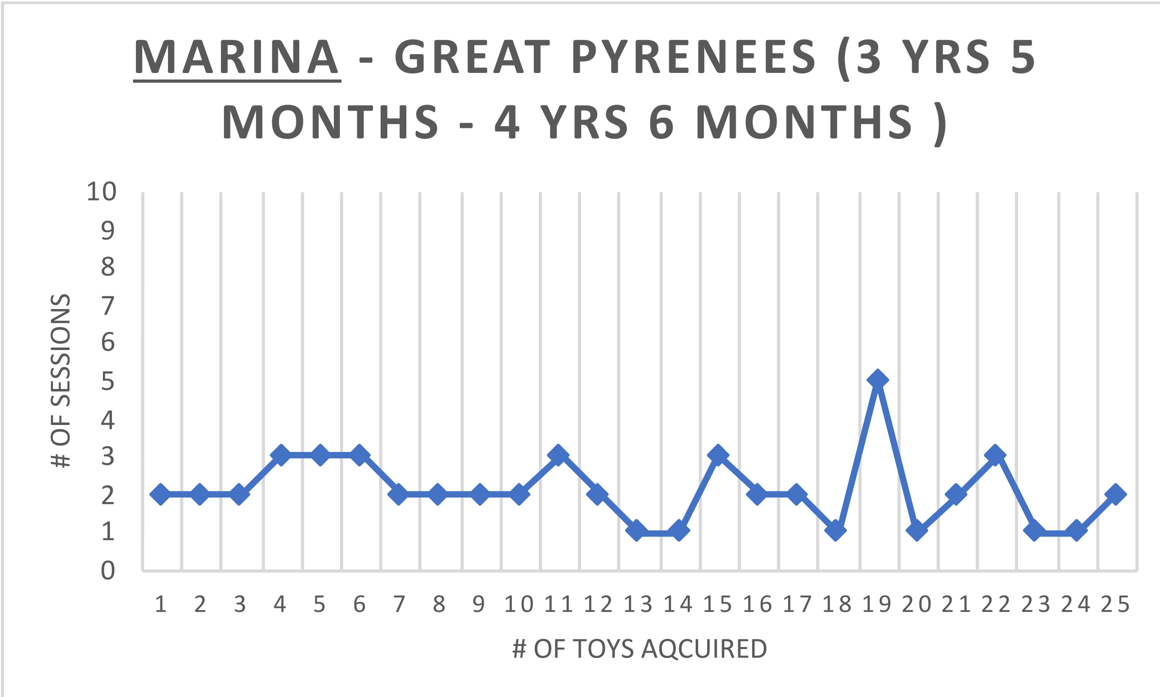


*Figure 7:* Acquisition data for Marina (great Pyrenees, female). X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

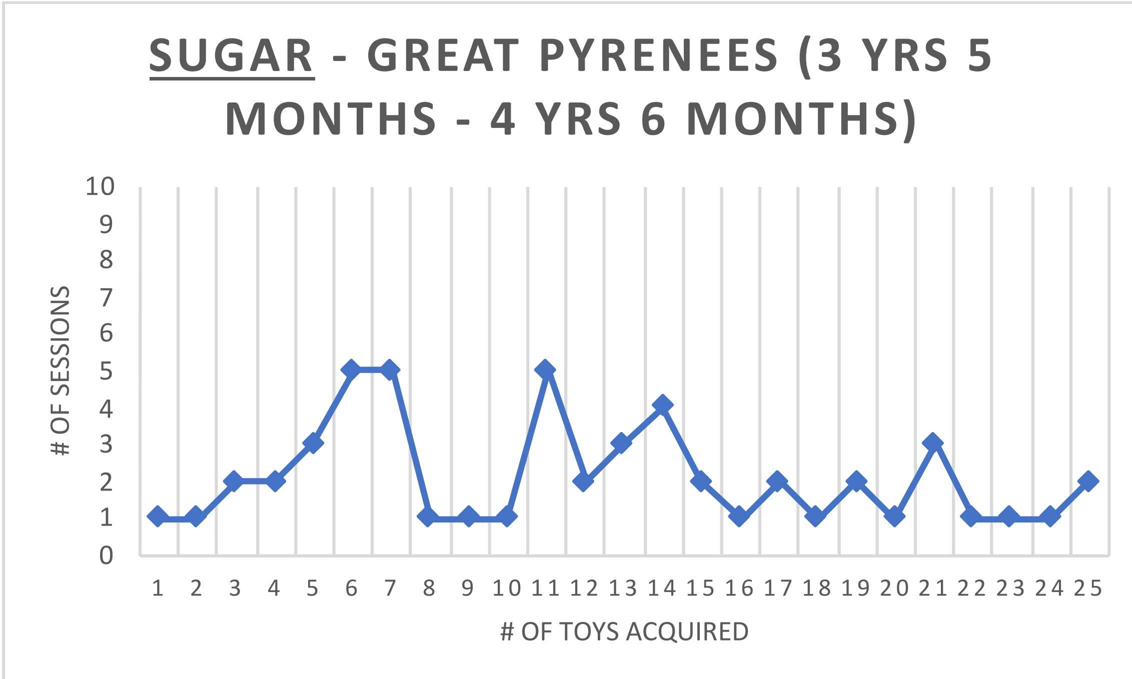


*Figure 8:* Acquisition data for Sugar (great Pyrenees, female). X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

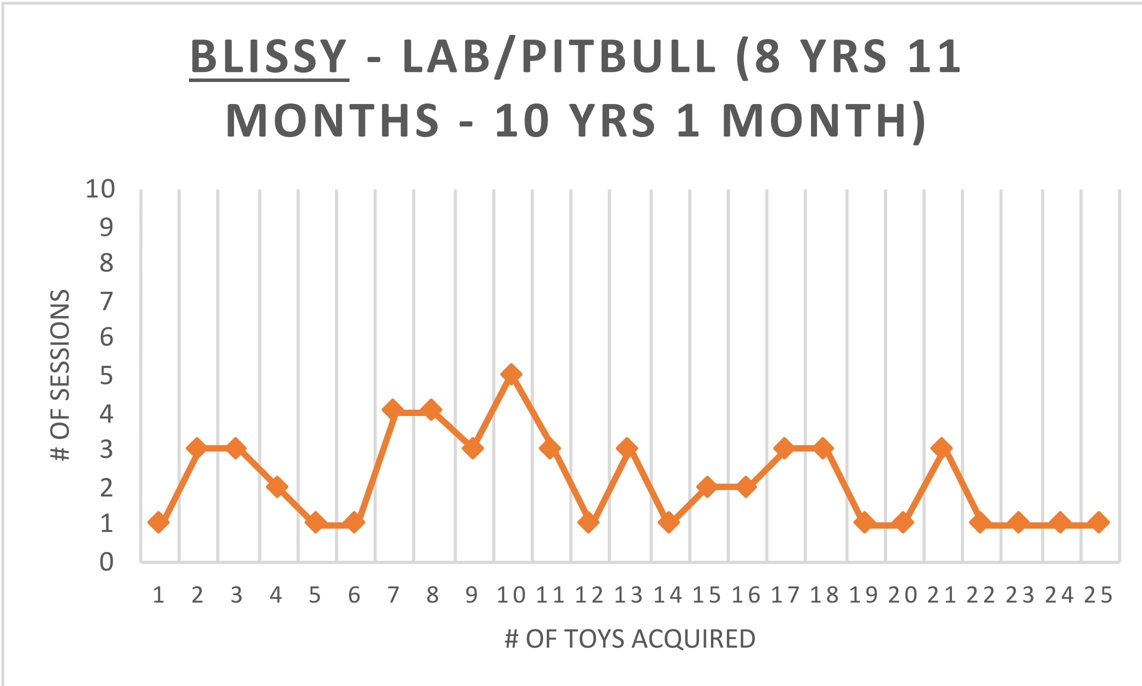


*Figure 9:* Acquisition data for Blissy (lab/pitbull mix, female). X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

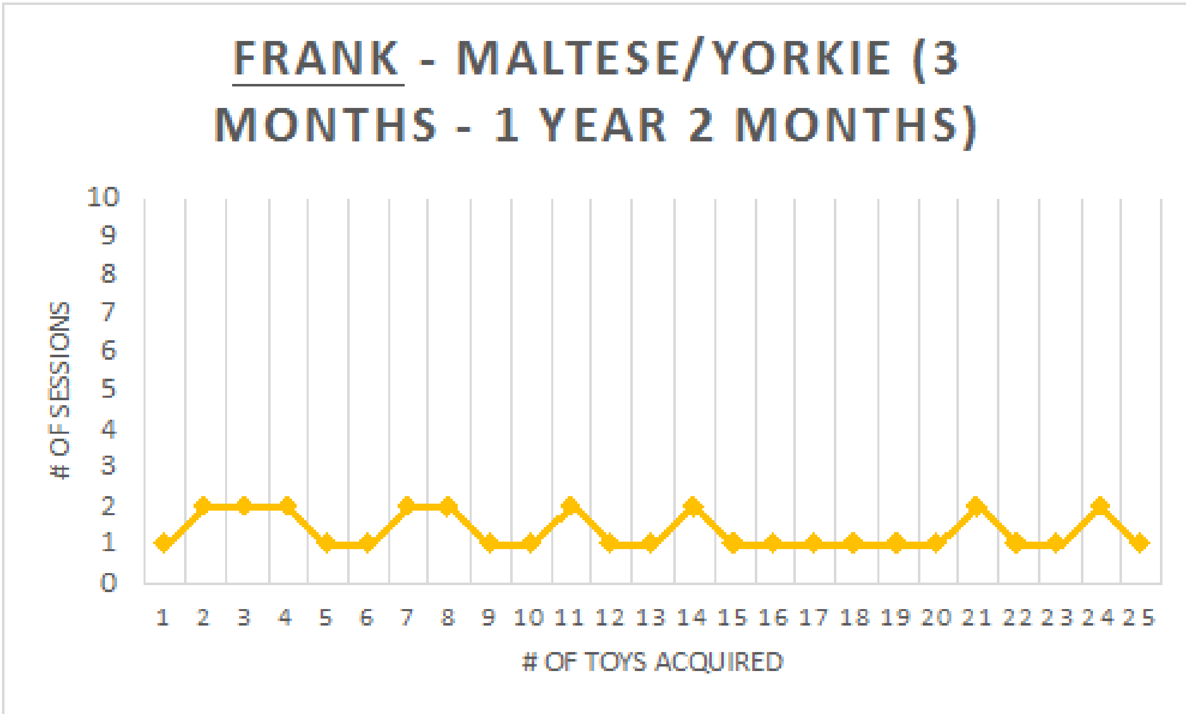


*Figure 10:* Acquisition data for Frank (Yorkshire terrier/Maltese mix, male). X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

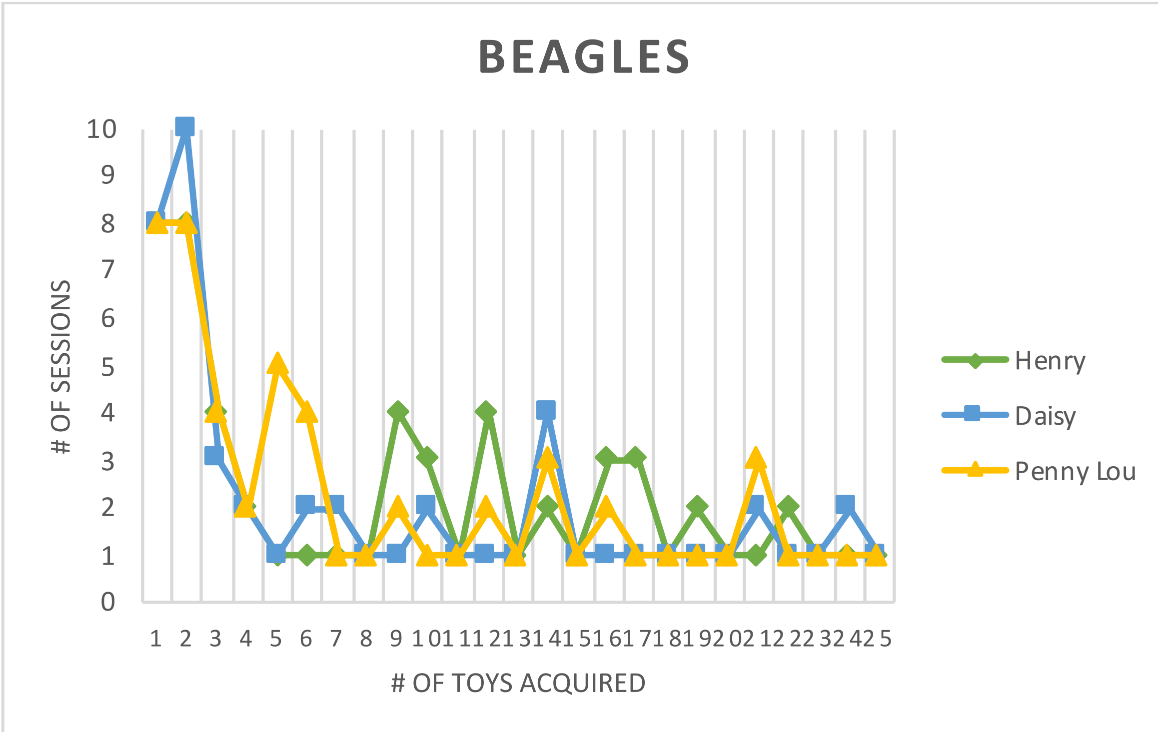


*Figure 11:* Acquisition data for all three beagles. Green represents Henry, blue represents Daisy, and yellow represents Penny Lou. X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

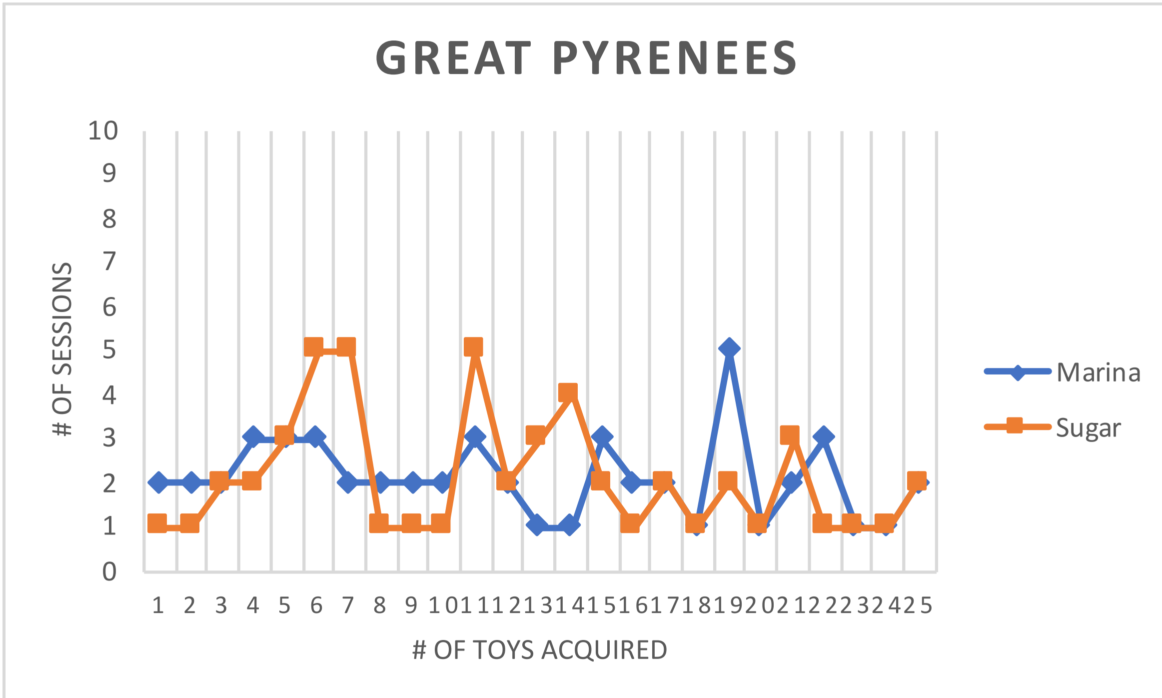


*Figure 12:* Acquisition data for the two great Pyrenees. Blue represents Marina and orange represents Sugar. X-axis represents the number of object names learned. Y-axis represents the number of sessions required to reach learning threshold.

| | Breed | Age | Mean # of trainings to learn 1 word | Range of trainings to learn 1 word | Total # trainings required to reach 25 words |
|---|---|---|---|---|---|
| **Henry** | Beagle | 6 months – 1 year 6 months | 2.32 | 1-8 | 58 |
| **Daisy** | Beagle | 6 months – 1 year 4 months | 2.08 | 1-10 | 52 |
| **Penny Lou** | Beagle | 6 months – 1 year 5 months | 2.28 | 1-8 | 57 |
| **Marina** | Great Pyrenees | 3 yrs 5 mo – 4 yrs 6 mo | 2.12 | 1-5 | 53 |
| **Sugar** | Great Pyrenees | 3 yrs 5 mo – 4 yrs 6 mo | 2.12 | 1-5 | 53 |
| **Blissy** | Lab/Pitbull mix | 8 yrs 11 mo – 10 yrs 1 mo | 2.16 | 1-5 | 54 |
| **Frank** | Maltese/Yorkie mix | 3 months – 1 year 2 months | 1.36 | 1-2 | 34 |

*Figure 13*: This table represents the mean and range of the number of sessions required before reaching the toy learning threshold for each toy, and the total number of sessions required to reach 25 words.

| | Breed | Age | Toy 5 | Toy 10 | Toy 15 | Toy 20 | Toy 25 | Total | % |
|---|---|---|---|---|---|---|---|---|---|
| **Henry** | Beagle | 6 months – 1 year 6 months | 4/8 | 4/8 | 4/8 | 0/8 | 5/8 | 17/40 | 42.5% |
| **Daisy** | Beagle | 6 months – 1 year 4 months | 6/8 | 2/8 | 4/8 | 4/8 | 4/8 | 20/40 | 50% |
| **Penny Lou** | Beagle | 6 months – 1 year 5 months | 6/8 | 3/8 | 3/8 | 2/8 | 6/8 | 20/40 | 50% |
| **Marina** | Great Pyrenees | 3 yrs 5 mo – 4 yrs 6 mo | 3/8 | 2/8 | 2/8 | 4/8 | 0/8 | 11/40 | 27.5% |
| **Sugar** | Great Pyrenees | 3 yrs 5 mo – 4 yrs 6 mo | 7/8 | 1/8 | 2/8 | 0/8 | 3/8 | 13/40 | 32.5% |
| **Blissy** | Lab/Pitbull mix | 8 yrs 11 mo – 10 yrs 1 mo | 0/8 | 5/8 | 3/8 | 3/8 | 2/8 | 13/40 | 32.5% |
| **Frank** | Maltese/Yorkie terrier mix | 3 months – 1 year 2 months | 2/8 | 2/8 | 4/8 | 1/8 | 3/8 | 12/40 | 30% |

*Figure 14*: Fast-mapping data for all dogs. Responses represent the number of times dogs correctly responded to the novel toy when given the novel toy’s name with no prior training.

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## BIOGRAPHY

Brianna L. Artz graduated from Battlefield Highschool in 2013. She received her Bachelor of Science in Psychology from George Mason University in 2017, completing the Honors in Psychology program. She decided to continue her graduate education in Psychology at George Mason University, and completed the requirements for her Mster of Arts in Psychology in the summer of 2019. She will continue her research and graduate career as a PhD student in Psychology at George Mason University.