2022

Owner Reported Outcomes on Two Psychometric Tests Do Not Predict Behavior on a Spatial Discounting Test.

Tracey E. Sellers-Sasher DVM
tsasher2501@gmail.com

Owner Reported Outcomes on Two Psychometric Tests Do Not Predict Behavior on a Spatial Discounting Test.

Abstract

Impulsivity is an inability to control inappropriate responses to stimuli in the environment. It refers to an inability to inhibit an action or to delay gratification for an immediate small reward versus a deferred large reward. Poor impulse control in dogs is a leading cause of owner relinquishment, rejection from assistance- and working-dog programs, and returns to shelter and foster care. The ability to reliably identify dogs who engage in impulsive behavior would improve these dogs' welfare by facilitating appropriate interventions in a timely manner. To investigate if the tendency of impulsive choice could be predicted by available psychometric tests, twenty-four dog/handler teams were recruited to participate in this study. All teams were composed of veterinary professionals employed at a single community animal hospital and their dogs. Handlers completed both the Canine Behavioral Assessment & Research Questionnaire (C-BARQ) and the Dog Impulsivity Assessment Scale (DIAS) psychometric tests. All dog/handler teams then completed a spatial discounting test, assessing their dog's ability to inhibit the choice of a close small food reward versus a more distant larger food reward. Twenty-one C-BARQ and DIAS sub-scales were found to have a statistically significant association. After performing a Bonferroni error correction calculation, two sets of pairwise associations related to arousability emerged as highly correlated and significant. However, we did not see a statistically significant association between C-BARQ, or DIAS sub-scales and maximum distance traveled in the spatial discounting test. This outcome raises the question of whether the attribution of impulsivity based on an owner reported questionnaire is subject to bias. Additionally, the spatial discounting test may not be an appropriate measure of impulsivity as a single test. The conclusion of this study suggests that veterinarians must carefully consider the limitations of behavioral diagnostic tests and be aware that erroneous results can influence welfare outcomes for companion dogs.

Degree Type

Thesis

Degree Name

Master of Science in Animal Welfare and Behavior (MSc AWB)

First Advisor

Jennifer Punt, VMD, PhD

Second Advisor

Thomas Parsons, VMD, PhD

Keywords

Animal, animal welfare, animal behavior, animal science

Owner Reported Outcomes on Two Psychometric Tests Do Not Predict Behavior on a Spatial Discounting Test.

Tracey E. Sellers-Sasher, DVM

Master of Science

Animal Welfare and Behavior

Spring 2022

Advisor: Jennifer A. Punt, VMD, PhD
Advisor: Thomas D. Parsons, VMD, PhD

Dedication

To all the dogs from whom I have learned so much, I am forever grateful.

We need another and a wiser and perhaps a more
mystical concept of animals. Remote from universal nature, and living by
complicated artifice, man in civilization surveys the creatures through the glass of his
knowledge and sees thereby a feather magnified and the whole in distortion. We
patronize them for their incompleteness, for their tragic fate
of having taken form so far below ourselves. And therein do we err, and greatly err.
For the animal shall not be measured by man.
In a world older and more complete than ours they move finished and complete,
gifted with extensions of the senses we have lost or never attained, living by voices we
shall never hear.
They are not brethren; they are not underlings:
they are other nations,
caught with ourselves in the net of life and time,
fellow prisoners of the splendor and travail of the earth.

Henry Beston
The Outermost House:
A Year of Life on the Great Beach of Cape Cod

Acknowledgements

I would like to thank
Noel Dybdal, DVM, PhD, DAVCP
Michael Melner, PhD
James Kepner, PhD
Jenni Punt, VMD, PhD
Tom Parsons, VMD, PhD, DACAW
Meghann Pierdon, DVM, DACAW
James Serpell, PhD
Carlo Siracusa, DVM, PhD, DECAWBM, DACVB
Darko Stefanofski, PhD
Victoria Carr
Kathryn Deans-Schaub
Suzanne Kapral
Morgan Hesko
Jonah Binstock
Chipo Siantumbu
May Truong
Ari and Megan
Ashlan and Jovany
Cato and Mike
Cooper and Jodi
Dixie and Brittany
Doobie and Amber
Fig and Myra
Hazel and Carol
Heidi and Jacqui
Jynx and Breezy
Kai and Janzell
Koda and Kim
Maikoh and Jonathan
Marcus and Myra
Marshmallow and Mike
Maui and Janzell
Monie and Amber
Tetris and Marion
Xander and Myra
Yeti and Megan
Shea and Molly
Jambi and Nadine
Sugar and Carol
Chance and Jacqui
I am grateful for your friendship, mentoring, and support,
I could not have accomplished this without your help.

Abstract

Impulsivity is an inability to control inappropriate responses to stimuli in the environment. It refers to an inability to inhibit an action or to delay gratification for an immediate small reward versus a deferred large reward. Poor impulse control in dogs is a leading cause of owner relinquishment, rejection from assistance- and working-dog programs, and returns to shelter and foster care. The ability to reliably identify dogs who engage in impulsive behavior would improve these dogs' welfare by facilitating appropriate interventions in a timely manner. To investigate if the tendency of impulsive choice could be predicted by available psychometric tests, twenty-four dog/handler teams were recruited to participate in this study. All teams were composed of veterinary professionals employed at a single community animal hospital and their dogs. Handlers completed both the Canine Behavioral Assessment & Research Questionnaire (C-BARQ) and the Dog Impulsivity Assessment Scale (DIAS) psychometric tests. All dog/handler teams then completed a spatial discounting test, assessing their dog's ability to inhibit the choice of a close small food reward versus a more distant larger food reward. Twenty-one C-BARQ and DIAS sub-scales were found to have a statistically significant association. After performing a Bonferroni error correction calculation, two sets of pairwise associations related to arousability emerged as highly correlated and significant. However, we did not see a statistically significant association between C-BARQ, or DIAS sub-scales and maximum distance traveled in the spatial discounting test. This outcome raises the question of whether the attribution of impulsivity based on an owner reported questionnaire is subject to bias. Additionally, the spatial discounting test may not be an appropriate measure of impulsivity as a single test. The conclusion of this study suggests that veterinarians must carefully consider the limitations of behavioral diagnostic tests and be aware that erroneous results can influence welfare outcomes for companion dogs.

Table of Contents

Introduction

Impulsivity is a trait that is related to inhibitory control and is described as a tendency to engage in hasty, inappropriate, and reckless actions and decisions. (Herman et al., 2018). A lack of self-restraint and an intolerance for delay of gratification are hallmarks of impulsive behavior. (Van den Bergh et al., 2006). Response inhibition deficits manifest as impulsive action, and delay aversion manifests as intolerance for postponement of gratification. Delay aversion contributes to several maladaptive responses with impulsivity as a central feature. (Van den Bergh et al., 2006) In people, impulsivity has been associated with impaired social interactions (Shoda et al., 1993) and lifelong struggles with ADHD, depression, OCD, addiction, and aggression (Moffitt et al., 2011; Callender et al., 2011). Negative impacts in the areas of education, career and earning opportunities, and stable, long-term personal relationships have been associated with a diagnosis of impulsivity early in life. (Bray et al., 2014) Whether impulsivity is a permanent behavioral trait or a learned response to environmental stimuli is not clear. (MacLean et al., 2014). What is clear is that ill-conceived decisions and actions can become a life-long attribute.

Multiple problem behaviors in dogs can be attributed to poor inhibitory control. Lack of inhibitory control is the single most important reason for abandonment to shelters and failure to succeed in service dog training. Problem behavior is the most common reason for relinquishment for dogs accounting for 47% of dogs entering shelters in this country. Each year approximately 3 million dogs enter shelters and approximately 670,000 are euthanized. (New et al.,2000; https://www.aspca.org/animal-homelessness/shelter-intake-and-surrender/pet-statistics) Masson & Gaultier,2018). Fifty to seventy percent of working dogs fail their service dog training due to lack of impulse control. (Brady et al.,2018; Bray et al., 2021). Many dogs fail to find a permanent home due to a lack of self-control and inability to learn preferred alternative behaviors. Owner frustration over how to manage and train these dogs leads to lack of emotional attachment and failure of the human animal bond. (Powell et al., 2021.) The welfare risks to these dogs include: 1. attribution of a permanent personality trait, 2. persistent social isolation, 3. persistent frustration and negative affective state, 4. relinquishment and potential euthanasia.

Self-control is a requirement for biologic fitness for all species. It is a requirement for the experience of positive emotions and affective states, and is fundamental for the experience of positive welfare. (Boissy et al., 2007). Impulsivity interferes with successful emotional regulation and appropriate response to stimuli within an environment. “Temperament” is defined in the Oxford dictionary as “a person’s or animal’s nature, especially as it permanently affects their behavior”. Temperament has been described as by Appleby as “the characteristics of individuals that describe and account for consistent patterns of feeling and behaving” in Animal Welfare (Appleby,2018, pg95). The study of maladaptive responses to stress has begun to correlate the relationship between elevated arousal states and behavioral characteristics of aggression, vigilance, and negative impact on learning ability (Beausoleil et al., 2012). Choice inhibition is based on emotional regulation and reflects the predominant neuroendocrine state of the individual. Display of impulsive behavior in a variety of settings can be a measure of long-term emotional state for an individual. (Wright et al., 2012). Temperament is reflected in an individual's response in a non-specific stress scenario in which we can measure underlying personality traits of distractibility, anxiety, and fear. Those emotional responses, which occur under elevated sympathetic nervous system tone, (SNS) compete with and inhibit other behavioral responses directed by the parasympathetic nervous system (PNS). Behavioral inhibition is the ability to suppress actions that are inappropriate or undesirable in a given context in reference to reward goals. (Bunford et al., 2019). It is an active process which occurs when the individual can ignore interference, from perceived and actual distractions, to successfully achieve a goal while avoiding non-productive behaviors. (Humby & Wilkinson, 2011). The degree of SNS tone and arousal state can be inferred by monitoring the animal's responses in test situations like the spatial discounting task and by recording physiological measures of alarm and increasing stress like heartrate variability (Tamioso et al., 2018)..

Research methods to study impulsivity include owner reported psychometric measurements, behavior measurements, and physiological measurements. The aim of this study was to collect data from two psychometric tests (the Canine Behavioral Assessment and Research Questionnaire [C-BARQ], the Dog Impulsivity Assessment Score [DIAS]), a behavioral test (a spatial discounting test [SDT]), and a physiological test (heart rate variability [HRV]), to determine if the psychometric and physiological tests would predict delay aversion on the behavioral test. The physiological test data, heart rate variability, collected during this study will be analyzed and reported at a future date. Our methods are included below, but our analysis will be the topic of another paper to follow.

The behavioral test measures the dog's tolerance for delay aversion through the ability to inhibit a choice for a small immediate food reward over a large, delayed food reward (Brady, et al., 2018). Heart rate variability has been shown to reflect an individual's underlying state of stress and provides an inference of SNS tone. (Zupan et al., 2016; von Borell et al.,2007; Katayama et al., 2016; Beauchaine & Thayer, 2015). C-BARQ and DIAS are validated owner reported psychometric tests which score specific sub-scales of behavior globally and impulsive behavior respectively (Serpell & Hsu, 2001; Mongillo et al., 2019; Wright et al., 2011). Scores are calculated from a five-point Likert scale. A higher score on the subset behaviors, other than Trainability, indicates less desirable behavior.

Behavioral and physiologic experimental data collection methods require a substantial time commitment, are labor intensive, and require special environmental considerations. In contrast, psychometric methods of data collection are rapid, readily available, and relatively inexpensive in time and resources. My goal was to determine if the C-BARQ and DIAS tests could predict outcomes on a delay aversion behavioral test. If so, psychometric testing could be administered in general practice to facilitate identification and early intervention for dogs with impulsivity at the core of their behavior problems.

I propose that C-BARQ and DIAS will be predictors of the tendency to discount quickly on a delay of reward task. I propose that the tendency to delay gratification on a spatial discounting task and psychometric assessments measure an animal’s ability to regulate emotional responses and adapt appropriately in their environment. By measuring DIAS and C-BARQ scores we will predict which dogs have fast discounting scores on a delay reward task. While impulsivity as a trait has been shown to be stable over time (Riemer et al., 2014) we do not know when the trait of impulsivity becomes a default tendency (Brady et al., 2018). Correlating psychometric assessments and behavioral measurements of impulsivity would suggest that we can rely on psychometric tests to identify dogs with the impulsive tendencies and provide treatment interventions that these dogs need, positively impacting their welfare.

Hypothesis: Adult dogs who have elevated scores on psychometric subset scales from the C-BARQ and DIAS behavior assessments, indicating a tendency for reactive and impulsive behavior, will have low maximum distance traveled measurements on a spatial discounting test.

Materials and Methods

All dogs were recruited from Pharr Road Animal Hospital staff. Their ages ranged from 1yr 4 months to 10 years old. Weights ranged from twelve to over one hundred ten pounds. The dogs were pure and mixed breeds who had been sourced from breeders and shelters. In one case an individual dog was being fostered and was adopted shortly after the conclusion of the testing. All dogs had a variety of obedience and training backgrounds, but none had extensive training. No dogs had any underlying cardiac, arthritic, other metabolic, or behavioral health issues. None of the dogs were on medications other than heartworm prevention and flea and tick medications. Most of the study participants were altered, but two intact males were within the study group. Four dogs did not complete the spatial discounting test or the heart rate tracings. One dog's owner did not complete the psychometric testing (Table 1).

Table 1. Study Dogs Demographic Data.

Name	Breed	Age	Weight LBS	Sex
Doobie	Cane Corso	2 Yr	110	M
Marshmallow	Pit Bull	6 Yr 6 Mo	100	M
Chance	Golden Retriever	13 Yr	87	M/N
Heidi	German Shepard	4 Yr	75	F/S
Marcus	Labrador Retriever	5 Yr	72.5	M/N
Yeti	GSP X	1 Yr 4 Mo	70	M/N
Shea	Labrador	10 Yr	63	F/S
Tetris	Rottweiler	4 Yr	61.5	F/S
Ari	Husky X	2 Yr 5 Mo	61	M/N
Jambi	PB	7 Yr	55	M/N
Kai	BC X	5 Yr 7 Mo	50	F/S
Maui	Dalmatian	4 yr 4 Mo	45	F/S
Sugar	Pit Bull X	4 Yr	45	F/S
Maikoh	Pit Bull X	1 Yr 8 Mo	41	M/N
Ashlan	Aussie X	1 yr 5 Mo	41	M/N
Dixie	Aussie	2 Yr 6 mo	40	F/S
Hazel	Pit Bull X	1Yr 9 Mo	39	F/S
Koda	German Shepard X	6 Yr 1 Mo	39.5	F/S
Jynx	German Shepard X	10 Yr 10 Mo	39	F/S
Monie	Schnauzer X	9 Yr 2 Mo	18.5	F/S
Fig	Terrier	12 Yr	18	M/N
Xander	Terrier X	7 Yr 6 Mo	14	M/N
Cooper	KCCS	1 Yr 7 Mo	12.7	M/N
Cato	TFT	5 Yr 6 Mo	12.6	M/N

Table 1. Study Dogs Demographic Data. *Twenty-four dogs participated in this study. Four dogs did not complete behavior testing and heart rate tracing. One owner did not complete the psychometric testing.*

Psychometric Questionnaires

C-BARQ

Pet guardians completed the C-BARQ behavior assessment profile as an evaluation of canine temperament and behavior. The C-BARQ was administered online, and 14 subscale scores were tabulated through the C-BARQ website, https://vetapps.vet.upenn.edu/cbarq/ (Table 2). Pharr Road Animal Hospital is a registered user of the C-BARQ assessment for this project. Results of the C-BARQ assessment will be provided to caregivers after data analysis.

C-BARQ is a 100-question owner/handler generated behavior survey for dogs. It is a validated instrument that has been used in over 50,000 behavioral assessments for the severity and frequency of 14 subscale behaviors (Powell et. al., 2021; Serpell et.al., 2005; Hare et.al., 2018).

Table 2. C-BARQ Subscale behaviors

Behavior Subscale	Population Average	Behavior Description
Stranger directed aggression	0.59	Aggressive displays toward strangers entering the dog or handler's home, territory, or personal space.
Owner-directed aggression	0.19	Aggressive behavior toward the owner/handler or other household members in response to manhandling, challenge, proximity to their body or high value possessions (food or objects) or being stared at.
Dog-directed aggression	0.97	Aggressive displays toward an unfamiliar dog approaching.
Dog directed fear	0.72	Vigilant, cautious responses when approached by unfamiliar dogs.
Familiar dog aggression	0.62	Threatening and aggression toward other household dogs.
Trainability	2.56	Attentiveness by the dog to the owner/handler, ability, and willingness to ignore distractions within the environment, compliance with simple cues, positive responses in the face of correction.
Chasing	2.09	Pursuing small animals if the occasion arises.
Stranger-directed fear	0.63	Vigilant and cautious responses when approached by unfamiliar people.
Nonsocial fear	0.76	Vigilant and cautious responses in the presence of unfamiliar objects, situations, and sudden loud noises.
Separation-Related Problems	0.56	Destructive behavior and vocalizations when separated from the owner, including physiological signs of stress and anxiety such as trembling, excessive salivation, anorexia, and restlessness.
Touch Sensitivity	0.68	Vigilant, cautious, and escape behaviors associated with restraint, bathing, nail trimming, or physical examination.
Excitability	2	Exuberant behavior in response to possible exciting and arousing events resulting in lack of self-control and difficulty calming.
Attachment/Attention Seeking	1.91	Maintaining close contact with owner/handler and soliciting attention and contact from the owner/handler, expresses agitation when engagement is withheld or directed at another household member.
Energy	1.95	The degree of excessive, exuberant, play behavior the dog displays.

Table 2. C-BARQ Subscales. *A higher score on the subset behaviors other than Trainability indicates less desirable behavior. If owner's have not observed their dog in the scenario described they are instructed to leave the question blank, if over 25% of questions are not answered for a subset it is coded as inconclusive (Powell et.al.,2021).*

DIAS

Pet guardians completed the DIAS behavior assessment as an evaluation of impulsivity. The DIAS was administered online, four scores related to impulsivity: the Overall Questionnaire Score (OQS), as well as three component factors of F1, Behavior Regulation, F2, Aggression and Response to Novelty, and F3, Responsiveness were calculated by the author according to the developer direction provided online, https://docs.google.com/forms/d/e/1FAIpQLSd36r4b5aNZPLD2elgMFsicvfPR_xogEWP_IgfuDzoF0agmFw/viewform (Table 3). The author has a product license to use the assessment during this project. Results of the DIAS assessment will be provided to caregivers after data analysis.

Table 3. DIAS Subscale Behaviors

Behavior Subscale	Normal Range	Behavior Description
OQS	0.42-0.62	Overall Questionnaire Score
F1	0.31-0.63	Behavior regulation evaluates arousal and impulse control, provides a focused measure for impulsivity, high score indicates little control in response to stimuli, little forethought prior to action, extreme physiological responses when excited.
F2	0.22-0.52	Aggression and Response to Novelty Lowered tolerance threshold for potential aversive stimuli, with expression of aggression behavior, frustration, and fear related in responses to novel situations/objects, high scores are associated with dogs who do not react well to novel situations/objects and likely to respond aggressively.
F3	0.57-0.83	Responsiveness general responsiveness and environmental awareness, reflects the dog's interest in the environment and trainability, high score indicates high trainability and quick reactions, long interest in stimuli/ low distractibility. While high responsiveness appears to be associated with quick action needed in some working situations a high overall impulsivity score appears to be associated with distractibility by environmental reinforcers (Concha et.al., 2021).

Table 3. DIAS Subscales. *18 survey items are used to provide an overall questionnaire score, OQS, Overall Questionnaire Score, for impulsivity and values for three underlying factors derived from principal component analysis from the original data. It is used to assess the trait of impulsivity and its contribution to frustration related behavioral problems in dogs, response to treatment interventions, as a tool to select working dogs where impulsivity is important to their success/failure, and in screening shelter dogs.*

Spatial Discounting Test

The Spatial Discounting Test, (SDT), parameters were based on the laboratory and field tests described in Brady, 2018. Modifications were made to the training protocol prior to the test for expediency. In the SDT the dogs were presented with two trays, one containing three pieces of food and the other containing one piece of food. The training session was to determine that the dog could distinguish between the large and small reward tray locations. Once the dog met criteria for training the test was conducted. An opaque barrier was placed on the centerline of the SDT field to ensure that the dog could not change their choice during the test. Testing consisted of a series of trials of tray presentation during which the dog could choose either the large or the small reward tray. Each time the dog chose the large reward tray the rewards would be replenished, and the tray would be moved 10 inches further from the start line while the small reward tray remained in the original position on the start line. The purpose of the test is to establish the maximum distance the dog will travel to obtain the large distant reward before opting to choose the small close reward.

Subjects

Twenty dogs completed the SDT. Sixteen dogs met the training criteria during the initial training session, four dogs required two training sessions to meet criteria. The SDT was performed once for all dogs.

Test set up and structure

The test was conducted at Pharr Road Animal Hospital on Saturday or Sunday when the practice was closed. A 35-foot by 20-foot lobby area was used as for the SDT. Two identical craft trays, Coobbar Plastic Arts and Crafts Trays, 11 x 8.3 x 1.2 inches, one blue and one yellow, were used for training and testing. The color and placement, on either side of the SDT centerline, of the large reward tray was randomized. The large reward tray contained three pieces of either Nature's Variety Freeze Dried Beef Mixers or 1/8th inch piece of Horizon mozzarella string cheese, the small reward tray contained one piece.

Figure 1.Spatial Discounting Test, (SDT) Testing field at Pharr Road Animal Hospital.

Tape was applied to the floor to facilitate rapid positioning of the dogs on the SDT centerline 36 inches from the field start line, and for accurate tray placement during the SDT. Each tray was positioned lengthwise at the start line and 10 inches to either side of the SDT centerline.

Figure 2. Spatial Discounting Test field."Heidi" during SDT training.

Dogs were handled by their owners. Handlers waited in an adjacent room to the test area. When the training/testing field was prepared the assistant would say “ready” and the handler would walk their dog to the start line, one meter from the test field and position the dog within a taped box on the floor which was on the centerline of the test field.

All dogs were kept on a short lead prior to reward choice. Owners dropped the lead to allow the dog’s choice to be unimpeded. The dog was collected after eating the chosen reward to avoid eating the remaining reward on the way back to the waiting area. Rewards were replenished and the large reward tray was repositioned if it had been chosen.

Figure 3."Xander" during SDT choosing large reward tray.

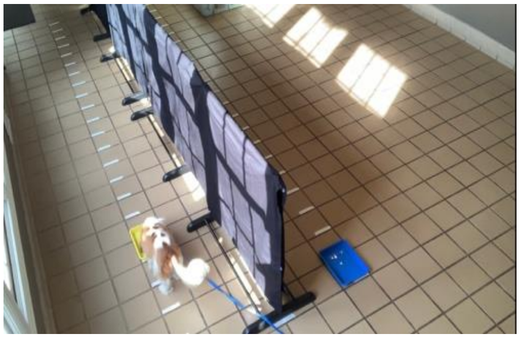


Figure 4."Cooper during the SDT, with the opaque barrier in place, choosing the large reward tray.

Training and testing were videoed for each dog. Two iPhones on tripods were placed at either end of the 8-meter test field to record each dog. Training sessions were conducted prior to testing. Both the large and small reward trays were positioned at the start line of the SDT field 10 inches on either side of the center line. Dogs had five trials of ten repetitions to meet criteria for testing. Training criteria was the large reward tray chosen in eight out of ten repetitions in two successive trials, with the last five repetitions of both trials being the large reward tray choice (S12). A ten-minute break was taken between training and testing.

During testing an opaque barrier was placed on the center line of the test field to prevent the dog from switching from one side to the other during the test. The dog had to choose the large reward tray at least once during the test. Tray placement on either side of the field center barrier during testing was randomized. Each time the large reward tray was chosen it would be moved 10 inches further away from the original start line for the next trial. The small reward tray remained at the start line position. Testing was discontinued when the dog chose the small reward tray in five consecutive trials and the distance was recorded (S13). Detailed information regarding the spatial discounting test is included in supplemental materials section (S1).

Heart Rate Variability Recording

Heart rate variability has been used as a proxy measurement of affective state due to cardiac system sensitivity to autonomic innervation influence. (von Borell et al., 2007). Normal sinus rhythm during rest and relaxed states of being, under high parasympathetic nervous system tone, is regularly irregular with high variability in inter-beat interval. During increased states of stress and arousal, under high sympathetic nervous system tone, the inter-beat interval becomes regular with low variability. Low heart rate variability has been associated with diminished emotional and behavioral regulation in animals and people.(Craig, et al., 2016). The Polar H10 heart rate sensor has been shown to detect, measure and report heart rate as effectively as ECG. (Essner et al., 2013; Jonckheer-Sheehy et al., 2012; Essner et al., 2015). Dogs with reported historic behavior problems have been shown to have lower heart rate variability compared to dogs who do not suffer from anxiety related behaviors (Wormald et.al., 2017). Heart rate variability has been used as a reference in dogs to assess an individual's anxiety, reflecting an inability to regulate emotional state and adjust appropriately to environmental stressors (Lensen et.al., 2017; Wormald et. al., 2016; Kuhne et.al., 2014).

Subjects

Heart rate tracings were obtained for 20 of 24 dogs. None of the test subjects had a history of current cardiovascular or systemic disease.

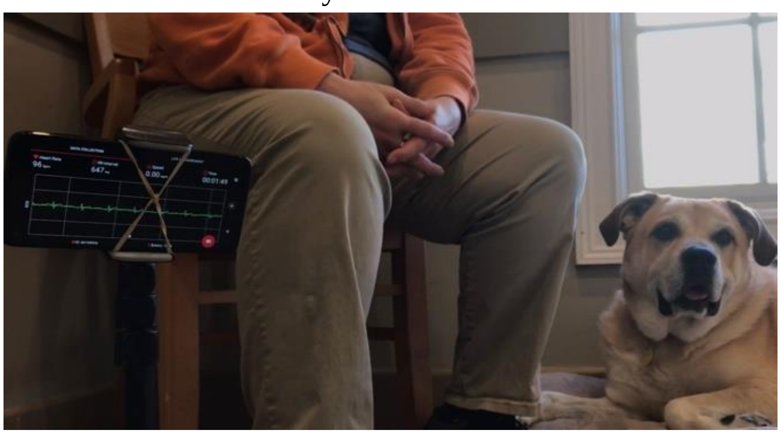


Figure 5. "Marcus" during in clinic heart rate tracing with owner.

Data Acquisition: In Clinic

All study dogs underwent three 10-minute heart rate tracing scenarios. Two in an exam room at Pharr Road Animal Hospital, during the first tracing the owner was present, during the second tracing the owner left the exam room while I remained. The third tracing was at home during a Zoom call meeting. Owners were given instruction for heart rate tracing set up, video camera placement, and heart rate app use during the in-clinic tracings in preparation for the at home heart rate tracing.

Heart rate tracings were recorded at PRAH in a 12 by 12-foot exam room. A bed for the dog and a chair for the owner were available for their use. Dogs were free to move around the exam room for five minutes to acclimate prior to the heart rate tracing. In the case of a heavy or long coat a small amount of hair was shaved caudal to the front legs around the ventral chest. Approximately 2 to 4 ml of spectra 360 12-08 electrode gel was applied to the Polar H10 heart rate monitor strap to facilitate signal conduction. The heart rate monitor was placed on each dog caudal to the front legs with the electrode portion of the strap over the area of strongest heartbeat palpation. The dog was not restrained during the tracing.

Figure 6."Chance" during in clinic heart rate tracing.

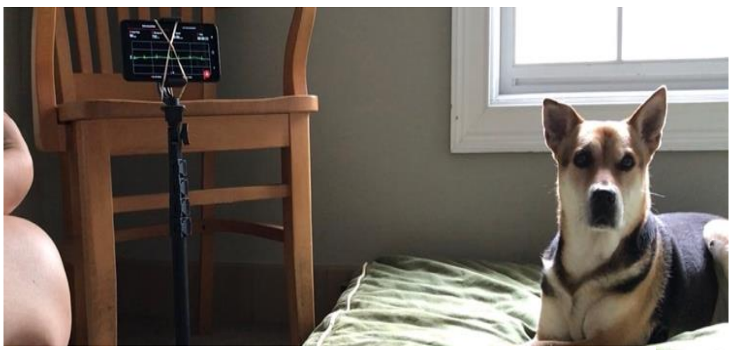


Figure 7. "Jynx" during in clinic heart rate tracing.

One ten-minute tracing was recorded with the owner present. During the second ten-minute tracing the owner left the exam room and waited in another room across the hall. The researcher remained in the exam room but did not interact with the dog during the tracing.

Video was taken during this segment to record changes in heart rate and tracing quality as well as behavioral conduct of the dog during the owner's absence. An additional 5 minutes of tracing and video was obtained during the owner's return to collect heart rate change, tracing quality, and reunion behavior.

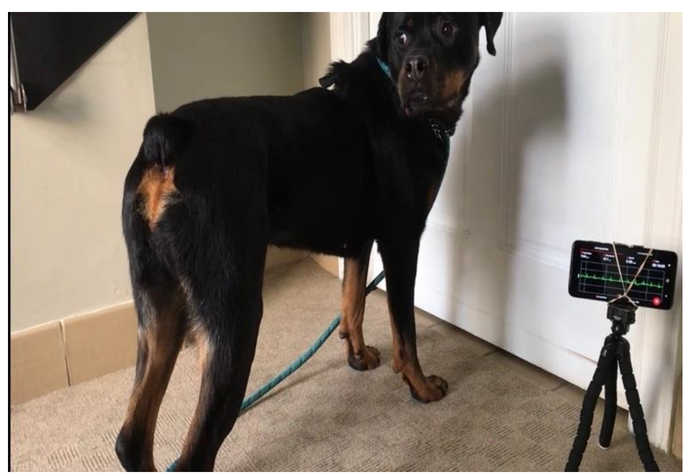


Figure 8."Tetris" heart rate tracing during owner's absence.

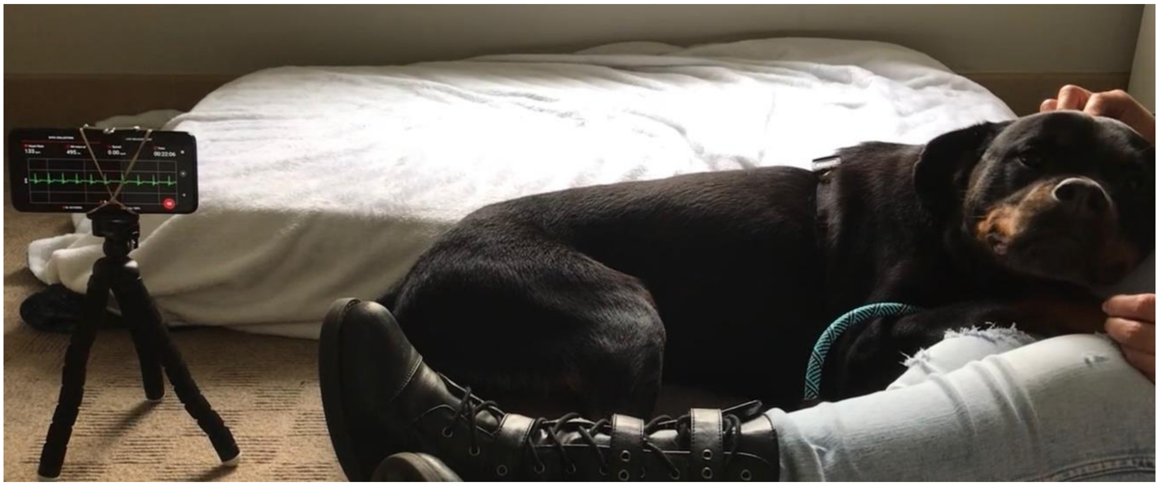


Figure 9. "Tetris" heart rate tracing during reunion with owner.

Data Acquisition: Zoom Meeting at Home

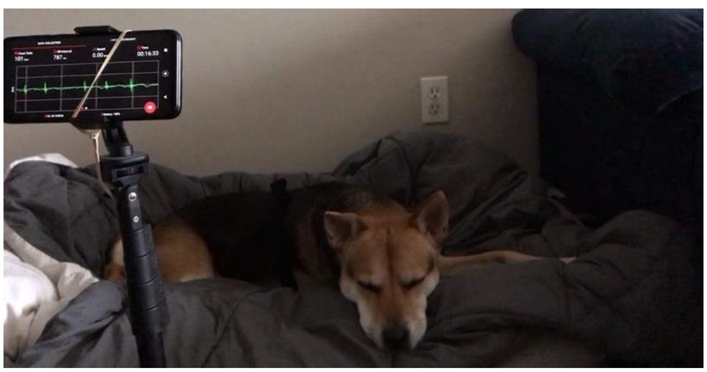


Figure 10."Jynx" during Zoom session at home heart rate tracing.

A Zoom meeting was scheduled with the owner. The owner took a “Home Recording Kit” with them the day of the in-clinic heart rate tracing containing, the Android smart phone with Polar Equine app, an iPhone to video the tracing and the dog’s behavior during the tracing, Spectra electrode gel, and rubber bands for shortening the heart rate strap if needed for small dogs (S10). Detailed written instructions for the at home heart rate tracing procedure are included in supplemental data (S1). The researcher sent the Zoom invitation and met with the owner at the scheduled time to assist the handler with the at home tracing and to record the Zoom meeting of the heart rate tracing in the dog’s normal environment. The at home heart rate tracing was the control to compare with the results of the in-clinic heart rate tracing.

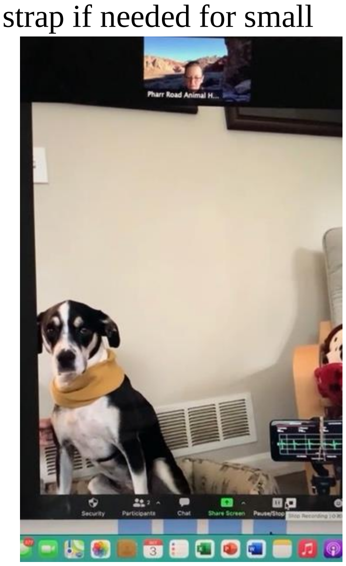


Figure 11. "Kai" during Zoom Session heart rate tracing at home.

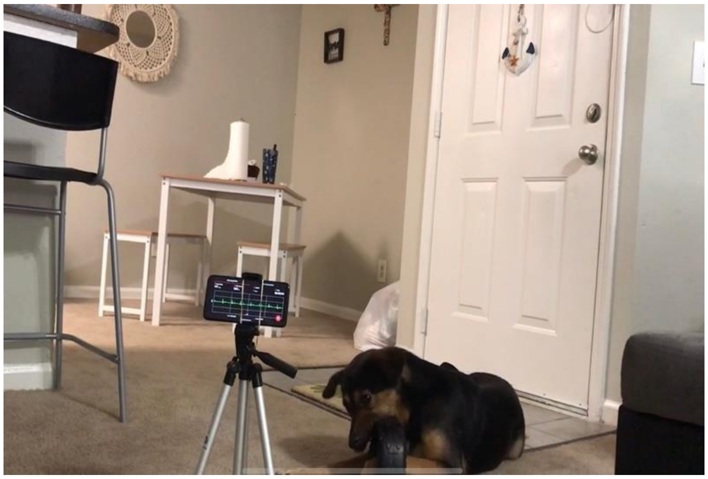


Figure 12. "Ashlan" during Zoom session heart rate tracing at home.

Heart rate tracings were recorded with the Polar equine app on an Android phone. Video was recorded on an iPhone to capture the heart rate monitor tracing and simultaneous dog behavior. At the conclusion of the tracing the electrode gel was cleaned from the dog's coat with warm water, and they were towel dried. Heart rate tracing data was downloaded from the app and will be analyzed at a future date.

Statistical Analysis

When it is likely that a scatterplot of the data will indicate a monotonic relationship, Spearman's correlation coefficient is appropriate for statistical analysis. Linear relationships occur when the change in one variable value is proportional to the change in the other value. A monotonic relationship is one that exists if as the value of one variable increases, the value of the other variable either increases or decreases, just not at a constant rate. (https://support.minitab.com/en-us/minitab-express/1/help-and-how-to/modeling-statistics/regression/supporting-topics/basics/a-comparison-of-the-pearson-and-spearman-correlation-methods/). Spearman's rank correlation rho, ρ, is a number from -1 to 1. Values close to the boundaries indicate a strong monotonic relationship between pairs of variables while, values close zero suggest that the variables are independent.

A Mann-Whitney test was used to evaluate whether the condition of weight or sex would predict maximum distance traveled. A Mann-Whitney is used to determine if there is a difference in the dependent variable, maximum distance traveled, for two independent groups. If the distribution of the dependent variable is the same for both groups, there is no evidence to support the research hypothesis.

The psychometric test data was evaluated using Minitab statistical data analysis software. A Spearman's rank correlation matrix of all subscale's associations from the C-BARQ and DIAS questionnaires was conducted. Additionally, C-BARQ subscales, DIAS subscales, and maximum distance traveled in the spatial discounting test were evaluated. Alpha was set to 0.05, the confidence coefficient was 0.95, and a p- value of 0.05 or less were parameters indicating significance for the Spearman's coefficient correlation, ρ. In hypothesis testing, alpha is the probability of concluding the research hypothesis is true when the null hypothesis is true instead. This mistake is called a Type 1 error. Alpha can be a value from 0 to 1. Often alpha is set at 0.05 meaning that there is at most a 5% chance of concluding that a pairwise association exists when the variables are independent. The confidence coefficient is how confident we are that the confidence interval will contain the parameter of interest, zero in the case of Spearman's ρ. When zero is not in the confidence interval it suggests that the variables may be monotonically associated. The p-value is the probability of obtaining an effect at least as extreme as the one in the sample data, assuming the null hypothesis is true. When p-values are less than or equal to alpha, they indicate significance, and the null hypothesis is rejected (Kim et.al., 2016; https://blog.minitab.com/en/adventures-in-statistics-2/understanding-hypothesis-tests-significance-levels-alpha-and-p-values-in-statistics?hs_amp=true; Wasserstein et.al., 2016).

Spearman correlation coefficient analysis of psychometric test variables

C-BARQ and DIAS scores are derived from a 5-point Likert scale. C-BARQ subset data is calculated for each participant's dog at the conclusion of the questionnaire. Their numerical score is reported with the population average for comparison. DIAS subset data was calculated by the author according to directions given on the DIAS assessment tool information page. (https://ipstore.lincoln.ac.uk/product/the-dog-impulsivity-assessment-scale-dias/download/317/133QIB). Population normal ranges are provided with the test assessment tool information. This data results in ordinal or ranked results. Results for each dog and the subscale population average or normal range are available in supplemental data. (S2)

The psychometric test data was evaluated by computing Spearman's rank coefficient correlation with Minitab statistical software between all pairs of variables from the C-BARQ and DIAS questionnaires (Table 4.). A Bonferroni error calculation correction was calculated for the data (Table 5). Test data for maximum distance traveled and C-BARQ and DIAS subscales were then evaluated (Table 6).

Bonferroni Method for controlling the experiment-wise error rate

The probability of committing at least one Type 1 error increases with the number of tests that are conducted. It is not possible to identify the specific unimportant associations present in a family of tests. It is possible to have one or more erroneous results in the 56 Spearman correlation coefficient calculations when the confidence coefficient is 0.95. To refine the statistical analysis, a Bonferroni correction was calculated to control the experiment-wise error rate for the entire family of tests. For two sided tests, the significance level, α, is divided equally into the upper and lower tails of the statistic's distribution. Thus, $0.05/56/2 = 0.0004$ is the probability of making a Type 1 error in either tail. The confidence coefficient is a probability that the confidence interval will contain zero or independence supporting rejection of the research hypothesis, in this case $1- 0.05/56 = 0.9991$. A confidence coefficient was calculated to be 0.9991, with alpha corrected to 0.0008, and P-value ≤ 0.0008 indicating significance.

Widening the confidence interval increases the probability that zero, or independence, is included in the intervals indicating that there is no evidence of a statistically significant monotonic association between variables. The Bonferroni analysis indicates strong evidence of a significant monotonic increasing relationship between chasing and F3, and touch sensitivity and F2, Rho for these two sets of variables is over 0.7 indicating the strength of the increasing association. Scatterplots for these two sets of C-BARQ and DIAS variables also indicate a non-linear monotonic increasing association. This work could be the basis for a follow-up randomized study to further investigate these associations and their relationship to companion dog behavior

Results

C-BARQ and DIAS Subscales Correlation

There are two psychometric tests that include measurements that relate to inhibition control. Both C-BARQ and DIAS are validated psychometric tests. The C-BARQ subscales titles are self-explanatory (Table 2). DIAS subscale Overall Questionnaire Score is a total impulsivity score. Overall Questionnaire Score is derived from three subcategories; F1 which relates to arousal and impulse control, F2 which relates to aggression and response to novelty, and F3 which relates to responsiveness and environmental awareness (Table 3).

We assessed whether C-BARQ and DIAS subscales are correlated. Twenty-two associations between C-BARQ and DIAS subscales were found to be statistically significant (Table 4). C-BARQ scores that measure fear, level of arousal, prey drive, intolerance to restraint, and defensive aggression are areas of interest that are associated with DIAS scores that measure environmental interest, distractibility, and quick decision making; expression of frustration, fear, and aggression in responses to unfamiliar situations/objects; and extreme physiological responses when excited which manifest in little impulse control.

The association of C-BARQ and DIAS subscale scores reflects the relationship between negative affective state and resulting behavior. Interestingly, the only negative monotonic association in the entire family of tests is between the C-BARQ subscale for Trainability and F1. A monotonic association exits between two variables in either of two states: (1) in a positive association as the value of one variable increases the value of the associated variable increases as well or (2) in a negative association as the value of one variable increases the value of the associated variable decreases, (in both cases at an uneven rate). As the score for Trainability increases the score for F1, extreme physiological responses when excited, decreases, and likewise as the score for Trainability decreases the score for F1 increases.

Table 4. C-BARQ and DIAS Spearman Coefficient Correlation

Set 1	Set 2	N	Correlation	95% CI for ρ	P-Value
OQS	Stranger-Directed Aggression	19	0.711	(0.327, 0.893)	0.001
F1	Stranger-Directed Aggression	19	0.510	(0.042, 0.795)	0.026
F3	Stranger-Directed Aggression	19	0.498	(0.027, 0.788)	0.030
OQS	Owner-Directed Aggression	19	0.523	(0.058, 0.801)	0.022
F2	Owner-Directed Aggression	19	0.562	(0.108, 0.822)	0.012
F3	Owner-Directed Aggression	19	0.583	(0.136, 0.833)	0.009
OQS	Dog-Directed Aggression	19	0.488	(0.015, 0.782)	0.034
F3	Dog-Directed Aggression	19	0.710	(0.327, 0.893)	0.001
OQS	Familiar Dog Aggression	19	0.616	(0.182, 0.849)	0.005
F3	Familiar Dog Aggression	19	0.537	(0.076, 0.809)	0.018
F1	Trainability	19	-0.494	(-0.786, -0.022)	0.032*
OQS	Chasing	19	0.626	(0.197, 0.854)	0.004
F3	Chasing	19	0.740	(0.377, 0.906)	0.000
OQS	Touch sensitivity	19	0.570	(0.118, 0.826)	0.011
F2	Touch sensitivity	19	0.746	(0.388, 0.908)	0.000
F2	Nonsocial Fear	19	0.494	(0.023, 0.786)	0.031
OQS	Separation-Related Problems	19	0.506	(0.037, 0.792)	0.027
OQS	Excitability	19	0.702	(0.313, 0.889)	0.001
F1	Excitability	19	0.559	(0.104, 0.820)	0.013
F3	Excitability	19	0.556	(0.100, 0.819)	0.013
OQS	Energy	19	0.702	(0.313, 0.889)	0.001
F1	Energy	19	0.695	(0.301, 0.886)	0.001

Table 4. C-BARQ and DIAS Spearman Coefficient Correlation. *Twenty-two C-BARQ and DIAS pairwise associations at α - 0.05, Confidence Coefficient – 95%, P-value $\leq$ 0.05 indicate a significant monotonic association. OQS-overall questionnaire score, F1-behavior regulation, F2- response to novelty and aggression, F3- environmental awareness and general responsiveness. * Indicates the only decreasing monotonic association in the family of tests, which indicates that as one variable increases the other decreases.*

Refinement of C-BARQ and DIAS Subscales Correlation

When many tests are run on the same set of data it is important to control the error rate, which is the probability of committing at least one Type 1 error. At a confidence coefficient of 95% there are 22 C-BARQ and DIAS variable correlations that have a p-value less than 0.05 (Table 4). The experiment-wise error rate for the twenty-two variable associations in Table 4 was corrected using a Bonferroni method calculation. Two pairs of C-BARQ and DIAS variables, Chasing/F3 and Touch Sensitivity/F2, emerged as having a statistically significant association (Table 5). The analysis indicates strong evidence of a significant monotonic increasing relationship with a high ρ value between Chasing/ F3, and Touch Sensitivity/F2.

Table 5. Bonferroni Corrected C-BARQ and DIAS Spearman Coefficient Correlation

Set 1-DIAS	Set 2-C-BARQ	N	Correlation	99.91% CI for ρ	P-Value
F3	Chasing	19	0.740	(0.013, 0.955)	$\leq 8 \times 10^{-4}$
F2	Touch sensitivity	19	0.746	(0.025, 0.956)	$\leq 8 \times 10^{-4}$

Table 5. Bonferroni Corrected C-BARQ and DIAS Spearman Coefficient Correlation. *Minitab statistical software was used to calculate Spearman's ρ at a confidence coefficient of 99.91%, α of 8 x 10-4, and a p-value* $\leq 8 \times 10^{-4}$. *Two C-BARQ and DIAS correlations have p-values less than or equal to* 8×10^{-4} *and zero was not within the confidence interval indicating a significant association. F3- environmental awareness and general responsiveness, Chasing- prey drive and pursuing small animals, F2- response to novelty and aggression, Touch sensitivity- frustration, fear, escape behaviors in response to intolerance to handling and restraint.*

Scatterplots for these two sets of C-BARQ and DIAS variables suggest a non-linear association as well (Figure 13). Elevated Chasing/F3 scores are representative of high distractibility by environmental stimuli. Elevated Touch Sensitivity/F2 scores reflect cautious, fearful responses to physical restraint or novel situations that may result in fear aggression and escape behavior. These results could be the basis for a follow-up study to further investigate the associations and their relationship to companion dog behavior.

Figure 13. C-BARQ and DIAS Subscale Association Scatterplots

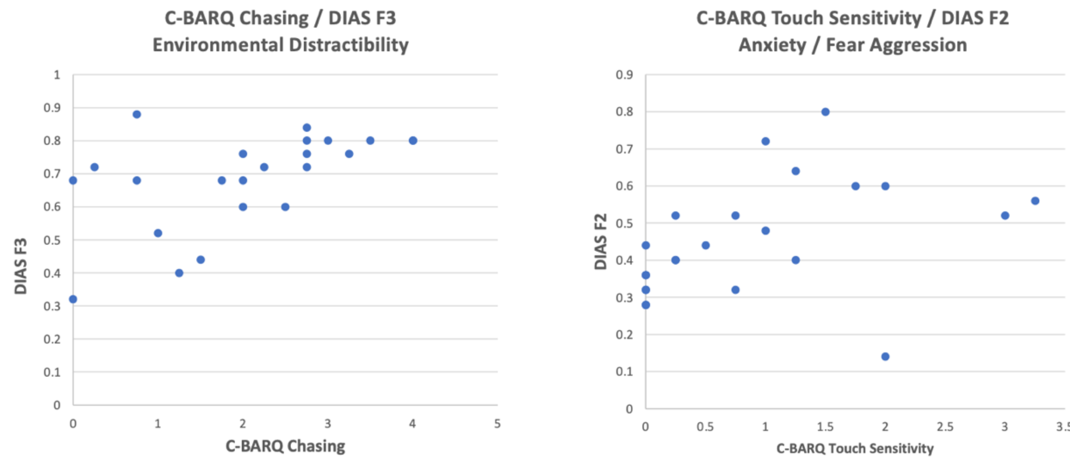


***Figure 13. Scatterplots of the association between Chasing/F3 & Touch Sensitivity/F2**. Chasing and Touch Sensitivity from the C-BARQ psychometric test, F2 and F3 from the DIAS psychometric test. A scatterplot whose results are represented by a curvilinear relationship in which as one variable value increases the associated variable value increases in an irregular order suggest a positive monotonic association.*

Correlation Between a Behavior Test vs Psychometric Test: Maximum Distance Traveled versus C-BARQ and DIAS Subscales

Our behavior test was based on the spatial discounting test from Brady's 2018 study that was determined to measure impulsivity. Based on Brady's study it was expected that the impulsivity subscales would be consistent with the behavior test results and that maximum distance traveled would be positively correlated with the psychometric tests. We expected that elevated DIAS and C-BARQ scores, particularly those assessing aggression, fear, excitability, energy, and trainability would correlate with early discounting. To evaluate the association between C-BARQ and DIAS subscales with maximum distance traveled in the spatial discounting test a Spearman's rank correlation was calculated (Table 6).

Table 6. Maximum Distance Traveled, MDT, x C-BARQ & DIAS Spearman Coefficient Correlation

Set 1-MDT	Set 2 C-BARQ & DIAS	N	Correlation	95% CI for ρ	P-Value
MDT	Stranger-Directed Aggression	19	-0.089	(-0.523, 0.381)	0.716
MDT	Owner-Directed Aggression	19	-0.132	(-0.555, 0.344)	0.589
MDT	Dog-Directed Aggression	19	-0.036	(-0.482, 0.425)	0.884
MDT	Dog-Directed Fear	19	-0.275	(-0.654, 0.214)	0.254
MDT	Familiar Dog Aggression	19	-0.243	(-0.632, 0.245)	0.317
MDT	Trainability	19	-0.108	(-0.537, 0.365)	0.659
MDT	Chasing	19	-0.012	(-0.464, 0.444)	0.960
MDT	Touch sensitivity	19	-0.281	(-0.657, 0.208)	0.244
MDT	Nonsocial Fear	19	-0.004	(-0.457, 0.451)	0.989
MDT	Separation-Related Problems	19	-0.266	(-0.647, 0.223)	0.272
MDT	Excitability	19	-0.061	(-0.502, 0.405)	0.803
MDT	Attachment/Attention Seeking	19	-0.057	(-0.499, 0.408)	0.816
MDT	Energy	19	0.077	(-0.392, 0.514)	0.755
MDT	OQS	19	-0.078	(-0.514, 0.391)	0.752
MDT	F1	19	-0.124	(-0.549, 0.352)	0.613
MDT	F2	19	-0.421	(-0.745, 0.062)	0.072
MDT	F3	19	0.063	(-0.403, 0.503)	0.799

Table 6. MDT vs C-BARQ and DIAS Scores. *MDT is a measure of impulsivity in a Spatial Discounting Test, (Brady et al., 2018). Alpha - 0.05, Confidence Coefficient – 95%, P-value ≤ 0.05. There was insufficient evidence to conclude a monotonic association between MDT and any of the 18 C-BARQ or DIAS variables. The CI includes zero for all correlations and p-values are greater than 0.05, indicating there is not sufficient evidence to conclude a statistically significant monotonic association between any test variables.*

None of the pairwise associations between variables for the C-BARQ or DIAS and maximum distance traveled had a p-value or confidence interval that indicated statistical significance (Table 6). Unexpectedly, these data indicate the psychometric subscales that we expected to predict behavioral outcome did not. This suggests that the psychometric tests and this behavioral test do not measure the same condition. Therefore, our prediction was not supported by the data; either the psychometric tests do not predict impulsivity, or the behavioral test did not measure impulsivity. While there were no statistically significant associations, F2 and maximum distance traveled p-value was 0.072. F2 assesses the dog's frustration, fear, and tendency to act in an aggressive manner in response to a novel situation or novel object. As a result, a study with adequate power may be valuable for investigating the negative affective state associated with these two variables more completely.

Body weight as a predictor of MDT

Bodyweight has been found to be a metric associated with decreased inhibition. (McGreevy, et. al, 2013; Clay et al. 2020; Salonen et.al., 2021; Mikkol et.al, 2021). Mean body weight from Clay, 2020, of 47 pounds was used to differentiate this study's participants into two groups. A Mann-Whitney statistical test was calculated to evaluate the distribution of maximum distance traveled in the two groups (S6). The p-value adjusted for ties was 0.061 which did not support statistical significance for weight as a variable predicting maximum distance traveled (Figure 14). Although the association between weight and maximum distance traveled was not statistically significant at these parameters the limited sample size of this study may not be appropriately powered to address this relationship. A more accurately powered sample size could reveal an association and be of interest in a future study.

Figure 14. Maximum Distance Traveled in Inches versus Weight in Pounds

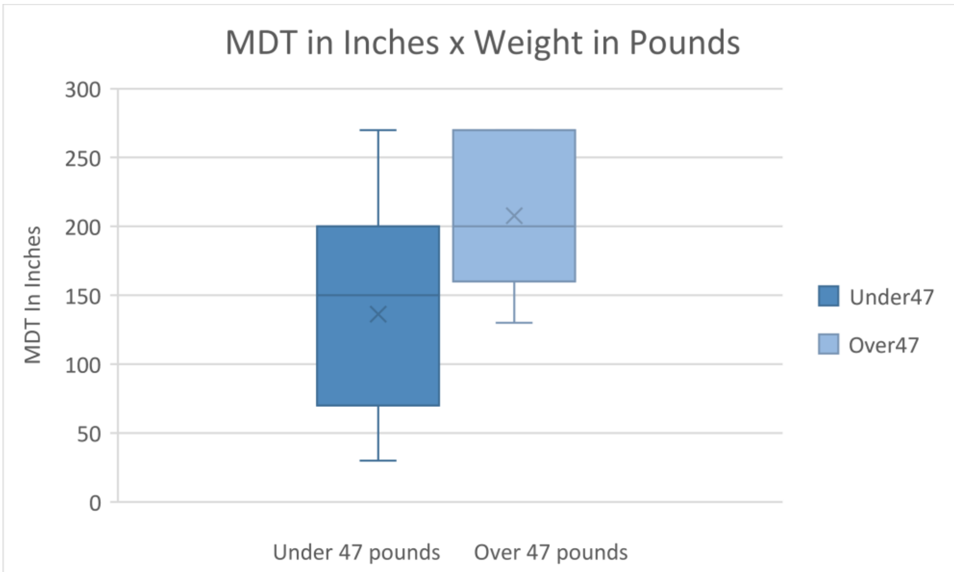


Figure 14. MDT in Inches versus Weight in Pounds. *Study subjects were divided into two weight groups based on Clay et al., 2020. Under and over 47 pounds groups were compared to maximum distance traveled using a Mann-Whitney calculation. Weight was not found to have a statistically significant relationship to maximum distance traveled. Achieved Confidence 95.18%, Adjusted for Ties W-value 90.50, P-value 0.061, (S6).*

Sex as a predictor for MDT

Fadel et. al., 2015.found that females engage in impulsive behaviors more frequently than males. A Mann-Whitney statistical test was calculated to analyze the distribution of maximum distance traveled between male and female study subjects (S7). The p-value adjusted for ties was 0.534 did not support statistical significance for sex as a predictor for maximum distance traveled (Figure 15).

Figure 15. Maximum Distance Traveled versus Sex

Figure 15. MDT versus Sex*. Study subjects maximum distance traveled were compared based on the criteria of sex using a Mann-Whitney calculation. Sex was not found to have a statistically significant relationship to maximum distance traveled. Achieved Confidence 95.09%, Adjusted for Ties W-value 134.50, P-value 0.534. (S7)*

Discussion

This study examined the association between two psychometric tests and a behavioral test focusing on impulse control in dogs. The Canine Behavioral Assessment and Research Questionnaire, C-BARQ, is a validated psychometric tool which provides a global personality profile. The Dog Impulsivity Assessment Scale, DIAS, is a validated psychometric tool which provides a personality score centered on the trait of impulsivity in dogs. Not surprisingly, this study found several C-BARQ and DIAS subscale correlations that related to owner reported problem behaviors. Additional statistical controls revealed C-BARQ subscale Chasing/ DIAS subscale F3, both of which are concerned with environmental distractibility, and C-BARQ subscale Touch Sensitivity /DIAS subscale F2, both of which are concerned with defensive aggression, have an especially strong association. We did not find a significant association between the psychometric test scores and behavioral test results. Additionally, physical properties of bodyweight and sex did not suggest a significant association with behavioral test results either. These results advance interesting considerations regarding problem behavior attribution and actions in dogs.

In brief, the C-BARQ subscale Chasing refers to the tendency to pursue small animals if the opportunity occurs, while F3 refers to the dog's responsiveness, interest in the environment, and distractibility by environmental reinforcers. Situational awareness is an evolutionarily influenced trait as well as an individually reinforced tendency. Environmental interest is desirable but must be placed under stimulus control for discretion or resulting behaviors can become unpredictable. A dog who is quickly distracted with environmental reinforcers, i.e., other dogs walking with their owners, often leaves their handlers struggling to recapture the dog's attention. Frustration associated with the inability to keep the dog's attention on task often leads to less interaction between dog and handler, without that interaction no new coping strategies are practiced.

As a reminder, Touch Sensitivity refers to vigilant, cautious, and escape behaviors associated with physical restraint and handling, while F2 refers to anxiety, fear, frustration, lowered tolerance to potential aversive stimuli and defensive aggression, particularly in response to novel objects and situations. Both Touch Sensitivity and F3 offer insights into an individual's "flight" tendency and intolerance to restraint. These dogs' tendency is to escape situations that are anxiety producing, but who will resort to defensive aggression when escape is eliminated as an option. Verbal reprimands and physical manipulation often exacerbate the dog's anxiety resulting in severe stress and increasing likelihood of aggression. As expected very little learning occurs in an extreme state of arousal due to divided attention and adverse effects on memory formation (Schwabe, L., et.al.2010). Often these dogs are considered untrainable by handlers, resulting in dismissal from formal training programs and decreased attempts to modify behavior by owners.

Additional provocative results that do not have statistical power emerged regarding owner bias, which must be a consideration in psychometric testing. Cavalli et al. (2017) speculate that in behavioral inhibition tests wide variation within the test scores can be an effect of overt influence of guardians during testing scenarios. It must be remembered that psychometric data is indirect and for that reason it can be influenced by bias. Psychometric test scores are derived from owner responses which may reflect historic discouragement and resignation. For example, one dog within this test group was rehomed following the completion of the C-BARQ questionnaire, but before the behavioral test was administered. Six weeks later the C-BARQ questionnaire was completed by the new owner (Figure 16a and Figure 16b). These results were used for association evaluation of the dog in the spatial discounting test. Interestingly, consistent with Cavalli's suggestion that psychometric tests do not measure behavior traits such as impulsivity directly, but instead the owner's subjective attribution of the trait in the dog, this dog's two sets of psychometric test scores are dramatically different. My own dog's C-BARQ scores were completed by two members of my family with dramatically different results (S5). Consistent with these observations, Janis Bradley, Director of Communications & Publications for the National Canine Research Council, at a recent talk hosted by Maddie's Fund, noted "how we categorize behavior, and name those categories, often reveals more about our biases than the subjects of those studies" (Bradley, J., "Irreconcilable Differences? Maybe Not!". Big Dog Master Class, Maddie's Fund, virtual, 03/29/22).

Figure 16a. Previous owner C-BARQ scores.

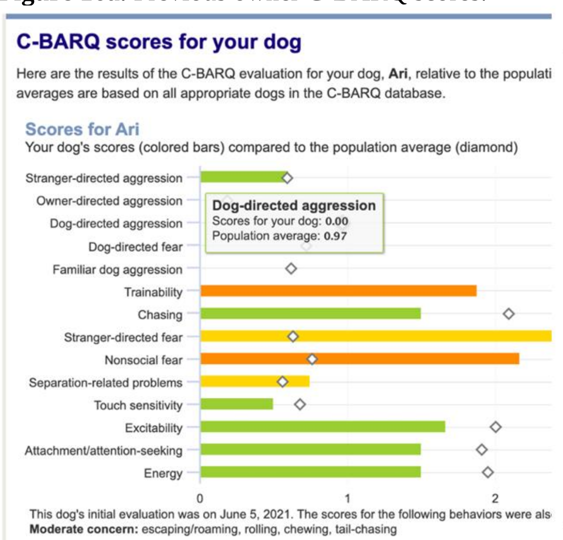


Figure 16b. Current owner C-BARQ scores.

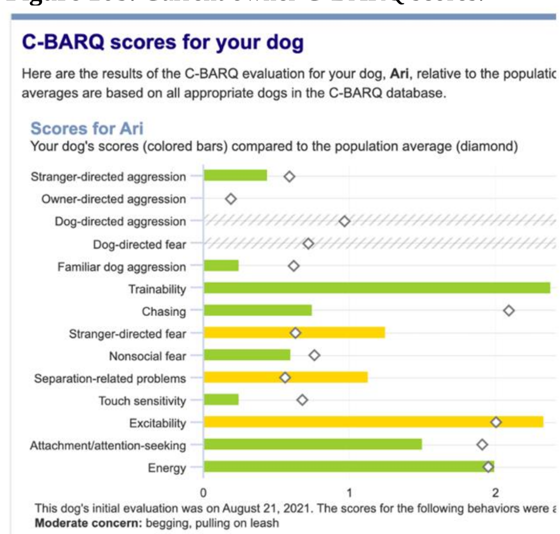


Figure 16. *C-BARQ scores for "Ari" from previous and current owners, completed on June 5,2021 and August 21,2021. The two different owners gave very different assessment answers that are reflected in significant score differences in Trainability, and Non-Social Fear. Interestingly, both owners did report behavior that resulted in scores for Stranger-Directed Fear and Separation-related problems that are higher than the population average.*

As is the case with many traits, the likelihood for a characteristic does not predict the certainty that a characteristic will be expressed. Characteristics are also subject to observer interpretation; for example, persistence can be described as perseverance or stubbornness. In a survey including both veterinarians and the public, respondents associated dog body size, coat color, and perceived reputation for aggression with reduced sensitivity to pain (Gruen et al.,2020). Social discrimination influencing attribution of sensitivity to pain based on specific physical characteristics has implications for appropriate recognition and management of pain. The results of the current study suggest social discrimination may also influence an owner's interpretation of the likelihood of impulsivity in dogs, offering the basis for a future study to investigate further.

In contrast to psychometric subscales associations, we found no significant association between C-BARQ subscales, DIAS subscales, sex, and weight with maximum distance traveled in a behavioral test of impulsivity. Under the conditions of this study the Spatial Discounting Test results did not correlate with either C-BARQ or DIAS questionnaire results, suggesting that the Spatial Discounting Test conducted is not a test for impulsivity. Conversely, as the questionnaire results also did not correlate with the Spatial Discounting Test outcome, they may not predict impulsivity. The complex relationship between context and individual temperament requires a variety of scenarios to reveal the tendency to act in a consistent manner. Conducting multiple behavioral assessments, testing different aspects of impulsivity, may suggest a more complete measurement of a dog's inhibitory control (Leonardi et al., 2012; MacLean et al., 2014; Brucks et al., 2017). Genetics, social learning, stress, fatigue, historic reinforcement, and feeding ecology have all been implicated in the capacity to exercise inhibitory control. (Vernouillet et al.,2016; MacLean et al., 2014; Brucks et al.,2017). Even within a specific breed the selection for type of work has been shown to be associated with differing expressions of impulsivity (Fadel et al., 2015).

Our analysis is based on a relatively small sample size and specific owner demographic group. All dogs recruited for participation in the study are owned by individuals working within the veterinary medicine field. It is possible there is greater interaction between these dog/handler teams than in the general population. These dogs may have benefited from more socialization than the general population of dogs and therefore these dogs were less inclined than the general population of dogs to show impulsive behaviors. This observation could be the basis for further investigation, including, for example, repeating the study with randomly selected companion dogs, shelter dogs and working dogs.

The possibility that neither psychometric test results or a spatial discounting test gives a full account of a study subject's inhibitory control suggest the complex nature of the questions; who will act impulsively, under what context are they more likely to behave inappropriately, can learning modify the tendency, and can labeling influence attribution? Are there dogs who have been labeled impulsive who in another setting would be labeled differently? Not because their behavior is different, but because the observer is different. Many dogs react when the doorbell rings, but not all people care. We must consider the affective state of the individual, the history of training and reinforcement, and the bias of the observer in the study of behavior incompatibilities.

Overall, our analysis attempted to identify associations between commonplace patterns of impulsivity through a maximum distance traveled behavioral test and psychometric test scores. The motivation for investigating whether an association could be identified was to use a readily available, less costly measurement tool to accurately diagnose a commonly reported behavior problem that can have devastating effects. Impulsivity is the behavioral outcome of a complex manifestation of psychological and physiological stress. The severity of the behavior is concluded from secondhand reporting, this further complicates evaluation due to bias. This study does suggest that assessment of environmental distractibility and fear aggression tested by C-BARQ and DIAS subscales of Chasing/F3 and Touch Sensitivity/F2 provide important clues about both handler and dog. Psychometric tests can be useful in revealing observer reported canine behavior patterns, but they should be interpreted with care and used as a part of a diagnostic behavior panel. Our study suggests that maximum distance traveled may not be a sufficient stand-alone measure of impulsivity. Testing multiple inhibitory control measurements would provide refinement of inhibitory control assessment (Brucks et al., 2017). Our results suggest that predicting impulsivity, while aspirational, requires careful consideration of measurement parameters involving dog, handler, context, and history. We are hopeful that that the analysis of physiological test data collected during this study, heart rate variability, will help disentangle the relationship between temperament, attribution, and behavior with impulsivity as a central feature of dog reported behavioral incompatibilities.

Bibliography

Beauchaine, T.P., & Thayer, J.F. (2015). Heart rate Variability as a Transdiagnostic Biomarker of Psychopathology. *International Journal of Psychophysiology, 98(2), 338-350.* https://doi.org/10.1016/j.ijpsycho.2015.08.004

Beausoleil, N.J., Blache, D., Stafford, K.J., Mellor, D.J., & Noble, A. D. L. (2012). Selection for Temperament in Sheep: Domain-General and Context-Specific Traits. *Applied Animal Behavior Science, 139(1-2), 74-85,* https://doi.org/10.1016/j.applanim.2012.02.020

Boissy, A., Dwyer, C. M., Jones, R. B. (2018). Fear and Other Negative Emotions. In Appleby, M. C., Olsson, I. A. S., Galino, F. (Ed.) *Animal Welfare, 3rd Edition (pg 95) CABI.*

Boissy, A., Manteuffel, G., Jensen, M. B., Moe, R. O., Spruijt, B., Keeling, L. J., Winckler, C., Forkman, B., Dimitrov, I., Langbein, J., Bakken, M., Veissier, I., & Aubert, A. (2007). Assessment of Positive Emotions in Animals to Improve Their Welfare. *Physiology & Behavior, 92(3), 375-397.* https://doi.org/10.1016/j.physbeh.2007.02.003

Brady, K., Hewison, L., Wright, H., Zulch, H., Cracknell, N., & Mills, D. (2018). A Spatial Discounting Test to Assess Impulsivity in Dogs. *Applied Animal Behavior Science, 202, 77-84,* https://doi.org/10.1016/j.applanim.2018.01.003

Bray, E. E., MacLean, E. L., & Hare, B. A. (2014). Context Specificity of Inhibitory Control in Dogs. *Animal Cognition,17(1), 15-31. https://doi.org/10.1007/s10071-013-0633-z*

Bray, E. E., Otto, C. M., Udell, M. A. R., Hall, N. J., Johnston, A. M., & MacLean, E. L. (2021). Enhancing the Selection and Performance of Working Dogs. *Frontiers in Veterinary Science, 8, 644431*. https://doi.org/10.3389/fvets.2021.644431

Brucks, D., Marshall-Pescini, S., Wallis, L. J., Huber, L., & Range, F. (2017). Measures of Dogs' Inhibitory Control Abilities Do Not Correlate Across Tasks. *Frontiers in Psychology, 8, 849.* https://doi.org/10.3389/fpsyg.2017.00849

Brunford, N., Csibra, B., Petak, C., Ferdinandy, B., Miklosi, A., & Gacsi, M. (2019) Associations Among Behavioral Inhibition and Owner-Rated Attention, Hyperactivity/Impulsivity, and Personality in the Domestic Dog (Canis Familiaris). *Journal of Comparative Psychology, 133(2), 233-243.* https://doi.org/10.1037/com0000151

Callender, K. A., Olson, S. I., Kerr, D. C., & Sameroff, A. J. (2010). Assessment of Cheating Behavior in Young School-Age Children: Distinguishing Normative Behaviors from Risk Markers of Externalizing Psychopathology. *Journal of Clinical Child and Adolescent Psychology: The Official Journal for the Society of Clinical Child and*

Adolescent Psychology, American Psychological Association, Division 53, 39(6), 776-788. https://doi.org/10.1080/15374416.2010.517165

Clay, L., Paterson, M. B. A., Bennett, P., Perry, G., & Phillips, C. C. J. (2020). Comparison of Canine Behaviour Scored Using a Shelter Behaviour Assessment and an Owner Completed Questionnaire, C-BARQ. *Animals, 10(10), 1797.* https://doi.org/10.3390/ani10101797

Concha, A. 10-14-21, 12th International Breeding Dog Conference, Effect of Impulsivity and Core Affect on Training Performance In Dual Purpose Military Working Dogs, [Power Point Slides], Texas Tech University, Lubbock, TX, LTC Holland Memorial Military Working Dog Veterinary Hospital, Lackland AFB, San Antonio, TX, College of Veterinary Medicine, North Carolina State University, Raleigh, NC, U.S. Army Research Office, Raleigh, NC. https://custom.event.com/E1CFFD772C6A4F4EA849D676C99D3C1C/files/db8694f5d37e4a5fb33bac3d5b1a5339.pdf

Craig, L. (2016). The Influence of Canine Aggression and Behavioral Treatment on Heart Rate Variability. Psychology Honors Project. Paper 39. https://digitalcommons.macalester.edu/psychology_honors/39

Dybdal, N. May 2, 2022, An Opportunity to Decrease Data Variability and To Improve Study Reproducibility: Allostatic State and Animal Welfare in Biomedical Research, [Power Point Slides], University of Pennsylvania College of Veterinary medicine, Animal Welfare and Behavior Master's Thesis presentation.

Essner, A., Sjostrom, R., Ahlgren, E., & Lindmark, B. (2013). Validity and Reliability of Polar RS800CX Heart Rate Monitor, Measuring Heart Rate in Dogs During Standing Position and at a Trot on a Treadmill. *Physiology & Behavior, 114-115, 1-5.* https://doi.org/10.1016/j.physbeh.2013.03.002

Essner, A., Sjostrom, R., Gustas, P., Edge-Hughes, L., Zetterberg, L., & Hellstrom, K. (2015). Validity and Reliability Properties of Canine Short-Term Heart Rate Variability Measures- A Pilot Study. *Journal of Veterinary Behavior,10(5), 384-390*. https://doi.org/10.1016/j.jveb.2015.05.006

Fadel, F. R., Driscoll, P., Pilot, M., Wright, H., Zulch, H., & Mills, D. (2016). Differences in Trait Impulsivity Indicate Diversification of Dog Breeds into Working and Show Lines. *Scientific Reports, 6(1), 22162*. https://doi.org/10.1038/srep22162

Gruen, M. E., White, P., Hare, B. (2020). Do Dog Breeds Differ in pain Sensitivity? Veterinarians and the Public Believe They Do. *PLos ONE 15(3):e0230315*. https://doi.org/10.1371/journal.pone.0230315

Hare, B. (2018). Domestication Experiments Reveal Developmental Link Between Friendliness and Cognition. *Journal Of Bioeconomics, 20(1), 159-163.* https://doi.org/10.1007/s10818-017-9264-9

Herman, A. M., Critchley, H. D., & Duka, T. (2018). Risk-Taking and Impulsivity: The Role of Mood States and Interoception. *Frontiers in Psychology, 9, 1625*. https://doi.org/10.3389/fpysg.2018.01625

Humby, T., Wilkinson, L. S. (2011). Assaying Dissociable Elements of Behavioural Inhibition and Impulsivity: Translational Utility of Animal Models. *Current Opinion in Pharmacology, 11(5), 534-539.* https://doi.org/10.1016/j.coph.2011.06.006

Jonckheer-Sheehy, V. S. M., Vinke, C. M., & Ortolani, A. (2012). Validation of a Polar Human Heart Rate Monitor for Measuring Heart Rate Variability in Adult Dogs Under Stationary Conditions. *Journal of Veterinary Behavior, 7(4), 205-212*. https://doi.org/10.1016/j.jveb.2011.10.006

Lensen, R. C. M. M., Betremieux, C., Bavegems, V., Sys, S. U., Moons, C. P. H., & Diederich, C. (2017). Validity and Reliability of Cardiac Measures During Behavioural Tests in Pet Dogs at Home. *Applied Animal Behaviour Science, 186, 56-63.* https://doi.org/10.1016/j.applanim.2016.10.011

Leonardi, R. J., Vick, S. J., & Dufour, V. (2012). Waiting For More: The Performance of Domestic Dogs (Canis Familiaris) on Exchange Tasks. *Animal Cognition, 15(1), 107-120*. https://doi.org/10.1007/s10071-011-0437-y

Katayama, M., Kubo, T., Mogi, K., Ikeda, K., Nagasawa, M., & Kikusui, T. (2016). Heart Rate Variability Predicts the Emotional State in Dogs. *Behavioural Processes, 128, 108-112.*

Kim, J., Bang, H. (2016). Three Common Misuses of P-values. Dental Hypotheses, 7(3), 73. https://doi.org/10.4103/2155-8213.190481

Kuhne, F., Hobler, J. C., & Struwe, R. (2014). Emotions in Dogs Being petted by a Familiar or Unfamiliar Person: Validating Behavioural Indicators of Emotional States Using Heart Rate Variability. *Applied Animal Behaviour Science, 161, 113-120.* https://doi.org/10.1016/j.applanim.2014.09.020

MacLean, E. L., Hare, B., Nunn, C. L., Addessi, E., Amici, F., Anderson, R. C., Aureli, F., Baker, J. M., Bania, A. E., Barnard, A. M., Boogert, N. J., Brannon, E. M., Bray, E. E., Bray, J., Brent, L. J. N., Burkhart, J. M., Call, J., Cantlon, J. F., Cheke, L. G., …Zhao, Y. (2014). The Evolution of Self-Control. *Proceedings of the National Academy of Sciences, 111(20), E2140-E2148.* https://doi.org/10.1073/pnas.1323533111

Masson, S., & Gaultier, E. (2018). Retrospective Study on Hypersensitivity-Hyperactivity Syndrome in Dogs: Long-term Outcome of High Fluoxetine Treatment and Proposal of a Clinical Score. *DOG BEHAVIOR, 4(2)*. https://doi.org/10.4454/db.v4i2.79

McGreevy, P. D., Georgevsky, D., Carrasco, J., Valenzuela, M., Duffy, D. L., & Serpell J. A. (2013). Dog Behavior Co-Varies with Height, Bodyweight, and Skull Shape. *PLos ONE, 8(12), e80529. Gale Academic OneFile*

Mikkola, S., Salonen, M., Puurunen, J., Hakanen, E., Sulkama, S., Araujo, C., & Lohi, H. (2021). Aggressive Behaviour is Affected by Demographic, Environmental, and Behavioural Factors in Purebred Dogs. *Scientific Reports,11(1), 9433.* https://doi.org/10.1038/s41598-021-88793-5

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hamcox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B.W., Ross, S., Sears, M R., Thomson, W. M., & Caspi, A. (2011). A Gradient of Childhood Self-Control Predicts Health, Wealth, and Public Safety. *Proceedings of the National Academy of Sciences, 108(7), 2693-2698*. https://doi.org/10.1073/pnas.1010076108

Mongillo, P., Scandurra, A., Eatherington, C. J., D'Aniello, B., & Marinelli, L. (2019). Development of a Spatial Discount Task to measure Impulsive Choices in Dogs. *Animals, 9(7), 469*. https://doi.org/10.3390/ani9070469

New, J. C., Salman, M. D., King, M., Scarlett, J. M., Kass,P.H., & Hutchison, J. M. (2000). Characteristics of Shelter-Relinquished Animals and Their Owners Compared With Animals and Their Owners in U.S. Pet-Owning Households. *Journal of Applied Animal Welfare Science, 3(3), 179-201*. https://doi.org/10.1207/S15327604JAWS0303_1

Powell, L., Stefanovsku, D., Siracusa, C., & Serpell, J. (2021). Owner Personality, Owner-Dog Attachment, and Canine Demographics Influence Treatment Outcomes in Canine Behavioral Medicine Cases. *Frontiers in Veterinary Science, 7, 630931.* https://doi.org/10.3389/fvets.2020.630931

Salonen, M., Mikkola, S., Hakanen, E., Sulkama, S., Puurunen, J., & Lohi, H. (2021). Reliability and Validity of a Dog Personality and Unwanted Behavior Survey. *Animals, 11(5), 1234.* https://doi.org/10.3390/ani11051234

Serpell, James A., & Hsu, Y. (2001). Development and Validation of a Novel Method for Evaluating Behavior and Temperament in Guide Dogs. *Applied AnimalBehaviour Science, 72(4), 347-364*. https://doi.org/10.1016/S0168-1591(00)00210-0

Serpell, J. A., & Hsu, Y. A. (2005). Effects of Breed, Sex, and Neuter Status on Trainability in Dogs. *Anthrozoos, 18(3), 196-207.* https://doi.org/10.2752/089279305785594135

Shoda, Y., Mischel, W., Wright, J.C. (1993). The Role of Situational Demands and Cognitive Competencies in Behavior Organization and Personality Coherence. *Journal of Personality and Social Psychology, 65(5), 1023-35*. doi:10.1037//0022-3514.65.5.1023.PMID:8246110

Tamioso, P. R., Maiolino Molento, C. F., Boivin, X., Chandeze, H., Andanson, S., Delval, E., Hazard, D., da Silva, G. P., Taconeli, C. A., & Boissy, A. (2018). Inducing Positive Emotions: Behavioural and Cardiac Responses to Human and Brushing in Ewes Selected for High vs Low Social Reactivity. *Applied Animal Behaviour Science, 208, 56-65*. https://doi.org/10.1016/j.applanim.2018.08.001

Van den Bergh, F., Spronk, M., Ferreira, L., Bloemarts, E., Groenink, L., Olivier, B., & Oosting, R. (2006). Relationship of Delay of Aversion and Response Inhibition to Extinction Learning, Aggression, and Sexual Behaviour. *Behavioural Brain Research, 175(1), 75-81*. https://doi.org/10.1016/j.applanim.2018.08.001

Vernouillet, A., Anderson, J., Clary, D., & Kelly, D. M. (2016). Inhibition in Clark's Nutcrackers (Nucifraga Columbiana): Results of a Detour-Reaching Test. *Animal Cognition, 19(3), 661-665*. https://doi.org/10.1016/j.bbr.2006.08.003

von Borell, E., Langbein, J., Despres, G., Hansen, S., Leterrier, C., Marchant-Forde, J., Marchant-Forde, R., Minero, M., Mohr, E., Prunier, A., Valance, D., & Veissier, I. (2007). Heart Rate Variability as a Measure of Autonomic Regulation of Cardiac Activity for Assessing Stress and Welfare in Farm Animals-A Review. *Physiology & Behavior, 92(3), 293-316.* https://doi.org/10.1016/j.physbeh.2007.01.007

Wasserstein, R. L., & Lazar, N. A. (2016). The ASA Statement on p-values: Context, Process, and Purpose. *The American Statistician, 70(2), 129-133.* https://doi.org/10.1080/00031305.2016.1154108

Wormald, D. (2017). Reduced Heart Rate Variability in Pet Dogs Affected by Anxiety-Related Behavior Problems. *Physiology and Behavior, 168, 122-127.*

Wright, H. F., Mills, D. S., & Pollux, P. M. J. (2011). Development and Validation of a Psychometric Tool for Assessing Impulsivity in the Domestic Dog (Canis Familiaris). *International Journal of Comparative Psychology, 24.210-225*

Wright, H. F., Mills, D. S., & Pollux, P. M. J. (2012). Behavioural and Physiological Correlates of Impulsivity in the Domestic Dog (Canis Familiaris). *Physiology and Behavior, 105(3), 676-682.*https://doi.org/10.1016/j.physbeh.2011.09.019

Zupan, M., Buskas, J., Altimiras, J., & Keeling, L. J. (2016). Assessing Positive Emotional States in Dogs Using Heart Rate and Heart Rate Variability. *Physiology & Behavior, 155(3), 102-111.* https://doi.org/10.1016/j.physbe.2015.11027

Supplemental Data

S1

Tracey Sasher
IACUC Application
Canine Impulsivity Study
VCSN635
Capstone Project
March 26, 2021

Biographical Sketch

Name -Tracey Sasher, DVM, CVA, CCRP, KPA-CTP
Position – Associate Veterinarian
Pharr Road Animal Hospital
553 Pharr Road NE
Atlanta, Georgia 30305
404-237-4601
tsasher2501@gmail.com

Institution and Location	Degree	Completion Date	Field of Study
Augustana College	BA	1984	Fine Art
University of Georgia	DVM	2002	Veterinary Medicine
Chi Institute	CVA	2004	Acupuncture
University of Tennessee	CCRP	2004	Canine Physical Rehabilitation
IAABC Consulting: Principles &Practice	Certificate	2018	Animal Behavior
Karen Pryor Academy	Certificate	2018	Karen Pryor Academy-Certified Training Partner
University of Pennsylvania	Certificate	2020	Animal Welfare and Behavior
University of Pennsylvania	MSc	Currently Enrolled	Animal Welfare and Behavior

Personal Statement

Behavior problems are the leading reason given by people worldwide for abandoning dogs. According to Maddie's Fund, behavioral problems are the principal reason for surrendering dogs. Behavior problems are the second most common cause of re-homing pets according to the ASPCA and are the primary reason given in the 2015 Affinity Foundation Study on animal abandonment, loss and adoption of pets in Spain. Impulsivity negatively impacts the ability to learn new tasks and is a primary criterion for dismissal from working dog programs. Lack of integration into an owner's home due to impulsive behavior, or a working dog training program results in frustration for the guardian and the dog. This often results in negative welfare for the dog and ultimately owner relinquishment. As a small animal-practitioner, I see the effect of canine reactivity and impulsivity weakening the human-animal bond, and the unfortunate outcome of unresolved behavior problems in owned dogs. My interest in this subject motivated me to pursue a research project to validate protocols that can be used in clinical practice to identify dogs with impulsivity traits. Early assessment and identification will provide the opportunity to intervene sooner and more effectively, resulting in better welfare outcomes for these dogs.

Project Summary

The overarching definition of impulsivity is *action without forethought, or the lack of consideration of a beneficial outcome for the actor*. In people impulsivity is associated with many psychiatric disorders including ADHD, addiction, depression, and aggression. In the dog impulsivity has often been studied in reference to aggressive behavior. Impulsivity has begun to be considered in broader, non-aggressive contexts in order create an assessment of a dog's tendency to act inappropriately as a trait, not as a condition of a state. Inhibition is the ability to suppress actions that are inappropriate or undesirable in a given context in reference to reward goals. (Bunford et al., 2019). Inhibition allows the actor/dog to ignore interference from perceived and actual distractions in the environment in order to successfully achieve a goal while avoiding non-productive behaviors. When inhibition does not occur maladaptive behaviors occur in the form of impulsive choices.(Humby & Wilkinson, 2011). The study of maladaptive responses to stress has begun to correlate the relationship between elevated arousal states and behavioral characteristics of aggression, vigilance, and reduced learning ability. (Beausoleil et al., 2012).

C- BARQ, the Canine Behavioral Assessment and Research Questionaire is a validated behavioral assessment tool for temperament evaluation for companion, service, and working dogs. It is a useful assessment tool for screening dogs for behavior problems by measuring the prevalence and severity of those behaviors. It has been validated as an assessment tool for service dog and pet dog temperament testing and has been used in approxiamtely 50,000 evaluations.

The Dog Impulsivity Assessment Scale is a validated behavior assessment tool used to assess impulsive tendencies in dogs using an owner reporting questionnaire. 18 criteria are used to provide an overall questionnaire score for impulsivity as well as scores for three underlying factors derived from the principal component analysis of original individual data. It is used to assess the trait of impulsivity and its contribution to frustration related behavioral problems in dogs, response to treatment interventions, as a tool to select working dogs where impulsivity is important to their success/failure, and in screening shelter dogs.

Temporal discounting tasks are an effective method for measuring tolerance of delay of reward delivery. Time to receipt of reward is an important criterion for goal directed behavior and decision making. The investment of time prior to reward presentation is perceived as a cost that is weighed against a beneficial future outcome. Smaller rewards that are accessible sooner are often preferred over uncertain future reinforcement. The value of the reward is discounted as a function of the postponement of presentation, particularly in an individual intolerant to delayed gratification. Temporal discounting tasks typically require longer training time in research settings and spatial discounting has been shown to be an effective means to measure impulsivity in reward choice based on effort of acquisition. Spatial discounting measures time to reward as well as effort, due to increased distance traveled for reward requiring longer goal directed behavior.(Brady et al., 2018)(Mongillo et al., 2019)(Stevens et al., 2005)

Heart rate variability is a measure of time between each heartbeat. The autonomic nervous system controls heartrate, blood pressure, respiratory rate and digestion. The two complimentary systems of the autonomic nervous system, parasympathetic and sympathetic, allow for appropriate responses to environmental stimuli/challenges. The parasympathetic nervous system, PNS, is often referred to as to as being responsible for rest and digest functions while sympathetic nervous system, SNS, is responsible for flight, flight, and freeze responses. Heartrate variability indicates the balance between these two systems. If SNS tone is elevated the time interval between heartbeats becomes more uniform, if the PNS tone is elevated the heartbeat interval variation is high. High heartrate variability in people is associated with emotional regulation at rest and during task events, people with higher heartrate variability are better able to regulate their emotional responses and focus during adverse task events. Low HRV in people is associated with elevated anxiety and depression while high HRV is associated with appropriate emotional regulation, decision making, and attention. Emotional responses in elevated arousal states occur during high SNS tone and compete with, and inhibit other behavioral responses directed by PNS tone. We can infer the degree of SNS tone and arousal state by monitoring an individual's responses in a non-specific stress test, as well as by recording physiological measures of alarm and increasing stress, namely heartrate and heartrate variability. (Appleby et al., 2018).

My project hypothesis is:

Adult dogs who have low heart rate variability, indicating high sympathetic tone, and high psychometric test scores on the C-BARQ and DIAS behavior assessments, indicating higher tendency for reactive and impulsive behavior, will have low maximum distance traveled measurements on a spatial discounting test.

Project protocols:

- All dogs will be recruited from and provided by employees from Pharr Road Animal Hospital.
- 25 dogs will be participating in this study.
- No invasive or painful procedures will occur during project protocols.
- Dogs included in the study are pet dogs with no behavioral or prohibitive orthopedic diagnosis.
- All dogs will have various levels of obedience training.
- Ages of participant dogs are 6 months to 10 years old.
- Gender, weight, and breed data will be included for all dogs tested.
- All respondents will provide informed consent to test/assess, handle, and feed dogs prior to study start date.
- The research project consists of three data collection scenarios: two psychometric tests, a spatial discounting test, and heart rate variability recordings in the clinic and at home.
- All dog handling protocols will be recorded on video.
- Owner will perform all dog handling procedures other than the in-clinic HRV tracing and DVM will provide client education for the at home heart rate variability recording.
- A PhD in Reproductive Endocrinology will assist during the Spatial Discounting Test to replenish reward trays and move the large reward tray to the next distant position. He will not interact with any of the dogs during the test but will make himself available for inspection by the participating dogs prior to the test.

Psychometric Testing

Pet guardians will complete the C-BARQ behavior assessment profile as an evaluation of canine temperament and behavior. The C-BARQ will be administered online, and the scores will be tabulated through the C-BARQ website, www.cbarq.org. Pharr Road Animal Hospital is a registered user of the C-BARQ assessment for this project. Results of the C-BARQ assessment will be provided to caregivers after data analysis.
Pet guardians will complete the DIAS as an evaluation of impulsivity trait as the Overall Questionnaire Score, OQS, as well as three component factors of Behavior Regulation, Aggression and Response to Novelty, and Responsiveness. The DIAS will be administered online with scoring tabulated by the researcher. Researcher has a product license to use

the assessment during this project. Results of the DIAS assessment will be provided to caregivers after data analysis.

Spatial Discounting Test

1. All training and testing sessions will be recorded,
2. All dogs will be held off food for four hours prior to the start of the test.
3. Guardians will sign release to administer test and provide food rewards. Food rewards will be either Horizon mozzarella cheese 1 cm^3 or Natures Variety Freeze Dried Beef Mixers.
4. Guardians will handle their dog in the training and testing phase.
5. Test site arrangement:
    a. Test will be conducted in a controlled, enclosed space, measuring at 5.5 x 10 meters at Pharr Road Animal Hospital.
    b. One meter will be measured from the wall to the dog start line.
    c. One meter will be measured from the dog start line to the training/testing field start line.
    d. The testing field will be marked in 25 cm increments from the field start line to 8 meters.

Training protocol

1. Two identical test trays, Coobbar Plastic Arts and Crafts Trays, 11 x 8.3 x 1.2 inches, one yellow and one blue will be used as reward trays.
2. The assignment of color for the large reward tray will be randomized for each dog.
3. The assignment of left or right position of the large reward tray will be randomized for each dog.
4. Trays will be positioned lengthwise on the field start line.
5. Dogs will be positioned in room adjacent to the test field blocking their view of the test field and the trays. Dogs will be on lead with their handler. The assistant will say “Ready” and the handler will walk the dog to the start line position 36 inches from the test field and will release the dog to the test field.
6. Both trays will be presented simultaneously.
7. Dogs will have up to five trials of ten repetitions to meet criteria for testing.
8. Dogs must meet criteria of large reward tray choice in eight out of ten repetitions in two successive trials, with the last five repetitions of both trials being the large reward tray choice.
9. Dogs will take a ten-minute break between training and testing.

Testing protocol

1. Test field will be as described above with the addition of a barrier placed on the midline of the field and reward trays positioned lengthwise at the field start line 25 cm from the midline.

2. The barrier ensures that when the dog makes a choice for a reward tray, they cannot change that decision and switch sides of the field.
3. Large reward tray color and left /right position of large reward tray will remain consistent from training scenario.
4. The dog will wait in the adjacent room with their handler until the alerted by the assistant “Ready” cue. The handler will then walk the dog to the test field on lead to position the dog one meter from the field start line and the reward trays.
5. The handler will drop the lead and the dog will be allowed to approach the test field and choose a reward tray to obtain the food reward. The handler will reduce the lead length and return to the adjacent room with the dog.
6. The assistant will replenish the reward tray and reposition the tray.
7. Each time the large reward tray is chosen it will be moved 25 cm further from the test field start line. If the small reward tray is chosen both trays remain at the preceding distance from the field start line.
8. Testing ends when the dog chooses the small reward tray five times in succession.
9. The distance to the large reward tray is measured and recorded as the maximum distance traveled, MDT. MDT is recorded from the front of the tray. All dogs must choose the large reward tray at least once for the MDT to be valid.

Heart Rate Variability Recording

In Clinic HRV Recording

1. All sessions will be recorded.
2. Guardian, dog, and researcher will enter exam room provided with dog bed and chair.
3. Dog chest circumference will be measured caudal to front legs. Dogs with heavy or long coat will have hair shaved in HRM strap position.
4. Guardian will be present for first heart rate variability, HRV, recording. Guardian will receive instruction during this recording on appropriate placement of heart rate monitor strap with electrode gel on their dog.
5. Polar H10 HRM strap will be adjusted to one inch shorter than chest circumference measurement to ensure a snug fit.
6. Polar H10 HRM will be prepared by attaching the connector to the strap and then applying approximately two ml of Spectra 360 12-08 electrode gel to electrode portion of HRM strap. HRM strap will be placed on dog chest just caudal to front legs with the connector located over the point of strongest heart-beat palpation.
7. Guardian will be instructed how to use Polar Equine HRV app on a provided smart phone. Polar Equine HRV app will be opened and a recording will be

selected. HRV recording will take 6 minutes. Heart rate variability will be recorded in the Polar Equine HRV app on the provided smart phone. Dog's name, date, time, and guardian present will be recorded in the notes section of the tracing. The recording will be saved.

8. The second HRV recording is identical to the first and will take place immediately after the first but, without the guardian present. The guardian will leave the exam room and wait quietly in the exam room across the hall. Researcher will conduct the second tracing. The dog's name, date, time and guardian absent will be recorded in the notes section of the tracing. The recording will be saved.
9. The owner will return to the exam room with their dog. The owner will be instructed how to remove the HRM strap, and how to clean electrode gel off the dog's skin with a damp towel.
10. The owner will be instructed to clean gel from the electrode portion of the HRM strap, disconnect the connector and replace the strap and connector in the carrying case for use at home.

At Home HRV Recording

1. Guardian will have written instructions for HRV recording at home.
2. Researcher will schedule a Zoom meeting with the Guardian to assist the HRV recording at home. The researcher will record the Zoom meeting and request that the smart phone be positioned on a tripod and with the screen in view during the recording.
3. Guardian will attach connector, apply electrode gel and place HRM strap on dog. Guardian will open Polar Equine HRV app on provided smart phone, choose a recording, take a 6-minute recording. The dog's name, date, time and home recording will be noted in recording notes section. HRV recording will be saved.
4. Researcher will assist with instructions to clean electrode gel from dog's skin. Researcher will assist with instructions for cleaning HRV strap, disconnecting connector, replacing HRM in case with smart phone, tape measure and tripod to return to researcher at their next scheduled workday.

Instructions for Guardian for at home heart rate variability recording:

1. Administer the heart rate variability recording in a quiet, comfortable place in your home where you will not be interrupted. Consider having a dog bed and a chew available for your dog if that is something they normally enjoy.
2. The circumference of your dog's chest that was measured at the clinic was _____. We measured the heart rate monitor chest strap one inch shorter to ensure a snug fit. Use the enclosed tape measure to confirm that the length of the heart rate monitor strap is ____.
3. Apply the connector to the heart rate monitor strap.
4. Apply approximately 2 ml Spectrum electrode gel to the rubber portion of the heartrate monitor strap. This side of the heart rate monitor will be in contact

with your dog's skin to get a good recording of your dog's heart rate variability.

5. Place the heart monitor strap on your dog.
6. Place the Android smart phone on the tripod. Place the iPhone on a second tripod and orient this device to record the Android phone displaying the ECG tracing of the heart rate as well as your dog.
7. Open the Polar Equine HRV app on the Android phone. Press the + sign in the center bottom of the app screen. Choose "Open HRV reading". Choose take test. The heart rate monitor will connect to the app and you will begin to see a tracing on the screen. Choose start reading and the tracing will be recorded. The recording will take 10 minutes.
8. I will be recording our Zoom meeting and will ask you to place the phone on the tripod where the screen can be seen during the tracing.
9. When the heart rate tracing is complete you will hear a chime. Choose "save". Choose the home icon on the far left at the bottom of the screen. Scroll down past "view all data". Scroll down to "Type your note here" and add your dog's name, the date, the time, and "at home tracing" in the notes section.
10. Remove the heart rate monitor strap from your dog and clean the gel from their skin with a damp towel.
11. Disconnect the connector. Clean the gel from the heart rate monitor strap with a damp towel and return the heartrate monitor strap and connector to the case. Return the tape measure, phone, and tripod to the case.
12. Return the case with the heart rate monitor, tripod, phone, and tape measure to me at your next scheduled workday.
13. THANK YOU for your participation in this research project!

S2

Table 3. Master Data Sheet-Name, Age, C-BARQ, DIAS Scores, Weight, MDT, Sex, Population Average, Normal Ranges

id	age	Stranger-Dir	Owner-Direc	Dog-Directec	Dog-Directec	Familiar Dog	Trainability	Chasing	Stranger-Dir	Touch sensit	Nonsocial Fe	Separation-R	Excitability	Attachment/	Energy	OQS	F1	F2	F3	weight	MDT	sex
Ari	2 yr	0.44	0	0	0	0.25	2.38	0.75	1.25	0.25	0.6	1.13	2.33	1.5	2	0.53	0.56	0.52	0.68	61	150	m/n
Ashlan	1.5 yr	0.7	0.13	0.75	0.33	0	1.88	0.25	0.75	1.25	1.17	1.25	2.83	2.33	2	0.64	0.68	0.64	0.72	41	200	m/n
Cato	6 yr	2.9	2.63	1.5	2.25	1.75	2.5	2.75	2	1	3	0.88	3.83	1.83	3	0.68	0.64	0.72	0.8	12.6	70	m/n
Cooper	2 yr	0	0	0	1	0	2.25	1	0	0.25	0.67	1.63	1.33	1.83	1.5	0.47	0.48	0.4	0.52	12.7	150	m/n
Doobie	5.75 yr	0	0	0.75	2.25	0	2.38	0	0.67	0.5	1	0.25	1.17	2	2	0.47	0.52	0.44	0.68	101	200	m
Fig	12 yr	0	0	0	0	0	3.29	0	0	0	0	0	1.67	1.33	0	0.28	0.22	0.32	0.32	18	90	m/n
Hazel	1.5 yr	0.6	0	1.5	3.75	1	2.5	2.75	2.5	1	0.17	0	3.2	3.5	3	0.61	0.64	0.48	0.72	39	80	f/s
Heidi	4 yr	0.8	0	4	0	0	2.88	4	0	0.75	0.83	0.38	2.67	2	2.5	0.61	0.58	0.52	0.8	75	270	f/s
Jynx	10 yr	0.9	0.13	1	1.75	0.75	2.63	2.25	2	2	1.5	0.5	2.33	2.5	2.5	0.51	0.46	0.6	0.72	39	200	f/s
Kai	5.75 yr	0.6	1.5	1	1	1.75	1.75	3	0.25	3	0.33	1.25	3	1.83	2	0.72	0.62	0.52	0.8	50	170	f/s
Koda	6 yr	0.4	0	1	1.25	0.25	2.13	2.5	2.25	3.25	1.67	1.25	1.17	2.33	2	0.49	0.46	0.56	0.6	39.5	30	f/s
Maikoh	1.5 yr	0	0	1	1.25	1	2	3.25	0.25	0	0.5	0.5	2.17	0.33	3	0.59	0.6	0.28	0.76	41	210	m/n
Marcus	5.5 yr	0.4	0	0	0	0	3.13	1.5	0	0	0.6	0	2.5	3.33	1	0.4	0.44	0.44	0.44	72.5	130	m/n
Marshmallo	6.75 yr	0	0	2.67	2	0	2.57	1.75	0	0	2.17	0	1.5	1.5	2	0.42	0.42	0.36	0.68	100	210	m
Maui	4.5 yr	1	0	1	1.25	0.5	2	2.75	1	0.25	0.17	2	2.67	2.67	3	0.68	0.68	0.4	0.76	45	40	f/s
Monie	9 yr	2	0.63	1.25	1.75	1.75	2.75	2.75	3.5	1.25	0.67	2.25	3.5	2.17	1.5	0.57	0.46	0.4	0.84	18.5	160	f/s
Tetris	4.5 yr	3.5	0	0.5	0	0.5	2.38	2	2	0.75	0.17	0.5	2.67	2.67	3.5	0.61	0.6	0.32	0.6	61.5	270	f/s
Xander	7.5 yr	0.4	0	0	0.5	0.25	1.13	1.25	0	0	0	0	2.67	2.8	1.5	0.44	0.46	0.32	0.4	14	270	m/n
Yeti	1.5 yr	0.2	0	0.5	0.5	0	2.38	2	0	0	1.17	1	2	2.17	2	0.5	0.46	0.28	0.76	70	270	m/n
Dixie	2.5 yr	0.7	0	3.5	1.5	3.5	3	3.5	1	0	0.5	0.13	3.5	4	4	0.6	0.56	0.36	0.8	40		f/s
Shea	10 yr	2.44	2.13	1.67	1.33	0	2.13	2	1.5	1.5	1.33	0.38	2	3.4	2	0.69	0.58	0.8	0.68	63		f/s
Jambi	7 yr	2.8	0	3.33	3.67	0.25	2.25	4	4	1.75	1.33	1.5	3	2.33	3	0.69	0.72	0.6	0.8	55		m/n
Sugar	4 yr	0	0	1.5	1.5	1	2.88	0.75	0	2	1	0	2.6	1.67	1	0.49	0.36	0.14	0.88	45		f/s
Chance	12 yr																			87	200	m/n
population average/norm		0.59	0.19	0.97	0.72	0.62	2.56	2.09	0.63	0.68	0.76	0.56	2	1.91	1.95	0.42-0.62	0.31-0.63	0.22-0.52	0.57-0.83			

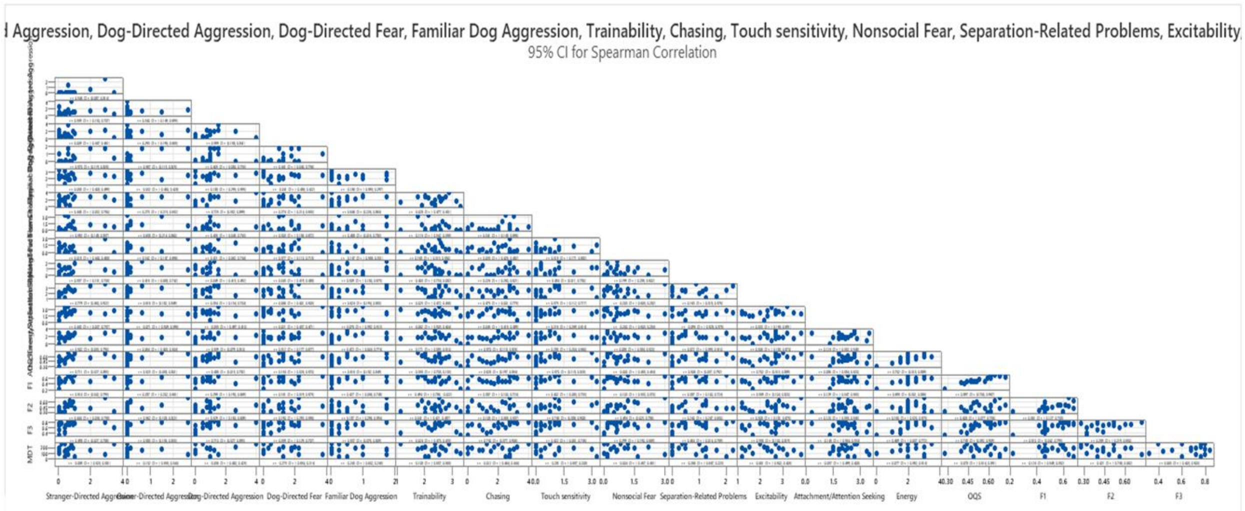
Dogs highlighted in yellow had two training sessions for SDT.

Legend for Table 3.

C-BARQ sub-scales	DIAS sub-scales	MDT- maximum distance traveled in inches	sex	weight in pounds
Stranger -directed aggression	OQS- overall questionnaire score		m/n - male neutered	
Owner-directed aggression	F1- Behavioral regulation		f/s - female spayed	
Dog-directed aggression	F2- Aggression and Response to Novelty		m - male	
Dog-directed fear	F3- Responsiveness			
Familiar dog aggression				
Trainability				
Chasing				
Stranger-directed fear				
Touch sensitivity				
Nonsocial fear				
Separation-related problems				
Excitability				
Attachment/attention seeking				
Energy				

S3 Spearman's Coefficient Correlation at 95% CI, alpha – 0.05, P-value ≤ 0.05

Correlation: Stranger-Directed Aggression, Owner-Directed Aggression, Dog-Directed Aggression, Dog-Directed Fear, Familiar Dog Aggression, Trainability, Chasing, Touch sensitivity, Nonsocial Fear, Separation-Related Problems, Excitability, Attachment/Attention Seeking, Energy, OQS, F1, F2, F3, MDT



Method

Correlation type Spearman
Number of rows used 19

ρ: pairwise Spearman correlation

Correlations

	Stranger-Directed Aggression	Owner-Directed Aggression	Dog-Directed Aggression	Dog-Directed Fear
Owner-Directed Aggression	0.546			
Dog-Directed Aggression	0.359	0.340		
Dog-Directed Fear	0.009	0.293	0.599	
Familiar Dog Aggression	0.570	0.567	0.405	0.441
Trainability	0.058	-0.032	0.188	-0.041
Chasing	0.448	0.273	0.725	0.274
Touch sensitivity	0.592	0.638	0.436	0.303
Nonsocial Fear	0.018	0.342	0.421	0.377
Separation-Related Problems	0.357	0.416	0.049	0.043
Excitability	0.779	0.616	0.354	0.066
Attachment/Attention Seeking	0.443	-0.071	-0.055	0.021
Energy	0.502	0.064	0.539	0.312
OQS	0.711	0.523	0.488	0.154
F1	0.510	0.287	0.299	0.161
F2	0.444	0.562	0.329	0.190
F3	0.498	0.583	0.710	0.359
MDT	-0.089	-0.132	-0.036	-0.275

	Familiar Dog Aggression	Trainability	Chasing	Touch sensitivity	Nonsocial Fear
Owner-Directed Aggression					
Dog-Directed Aggression					
Dog-Directed Fear					
Familiar Dog Aggression					
Trainability	-0.186				
Chasing	0.646	-0.028			
Touch sensitivity	0.488	-0.115	0.341		
Nonsocial Fear	-0.147	0.168	0.035	0.318	
Separation-Related Problems	0.309	-0.403	0.226	0.484	0.199

Excitability	0.624	-0.023	0.475	0.375	-0.203
Attachment/Attention Seeking	0.076	-0.062	0.045	0.216	-0.200
Energy	0.472	-0.171	0.570	0.285	0.085
OQS	0.616	-0.355	0.626	0.570	-0.000
F1	0.427	-0.494	0.387	0.402	-0.103
F2	0.187	0.041	0.108	0.746	0.494
F3	0.537	-0.024	0.740	0.422	0.299
MDT	-0.243	-0.108	-0.012	-0.281	-0.004

	Separation-Related Problems	Excitability	Attachment/Attention Seeking	Energy
Owner-Directed Aggression				
Dog-Directed Aggression				
Dog-Directed Fear				
Familiar Dog Aggression				
Trainability				
Chasing				
Touch sensitivity				
Nonsocial Fear				
Separation-Related Problems				
Excitability	0.163			
Attachment/Attention Seeking	-0.095	0.333		
Energy	0.072	0.306	0.124	
OQS	0.506	0.702	0.086	0.702
F1	0.387	0.559	0.129	0.695
F2	0.240	0.308	0.120	0.160
F3	0.464	0.556	-0.145	0.469
MDT	-0.266	-0.061	-0.057	0.077

	OQS	F1	F2	F3
Owner-Directed Aggression				
Dog-Directed Aggression				
Dog-Directed Fear				
Familiar Dog Aggression				
Trainability				
Chasing				
Touch sensitivity				
Nonsocial Fear				
Separation-Related Problems				
Excitability				
Attachment/Attention Seeking				
Energy				
OQS				
F1	0.897			
F2	0.408	0.361		
F3	0.748	0.510	0.269	
MDT	-0.078	-0.124	-0.421	0.063

Pairwise Spearman Correlations

Sample 1	Sample 2	N	Correlation	95% CI for ρ	P-Value
Owner-Directed Aggression	Stranger-Directed Aggression	19	0.546	(0.087, 0.814)	0.016
Dog-Directed Aggression	Stranger-Directed Aggression	19	0.359	(-0.130, 0.707)	0.132
Dog-Directed Fear	Stranger-Directed Aggression	19	0.009	(-0.447, 0.461)	0.972
Familiar Dog Aggression	Stranger-Directed Aggression	19	0.570	(0.119, 0.826)	0.011
Trainability	Stranger-Directed Aggression	19	0.058	(-0.408, 0.499)	0.815
Chasing	Stranger-Directed Aggression	19	0.448	(-0.032, 0.760)	0.054
Touch sensitivity	Stranger-Directed Aggression	19	0.592	(0.148, 0.837)	0.008
Nonsocial Fear	Stranger-Directed Aggression	19	0.018	(-0.440, 0.468)	0.942
Separation-Related Problems	Stranger-Directed Aggression	19	0.357	(-0.131, 0.706)	0.133
Excitability	Stranger-Directed Aggression	19	0.779	(0.450, 0.922)	0.000
Attachment/Attention Seeking	Stranger-Directed Aggression	19	0.443	(-0.037, 0.757)	0.057
Energy	Stranger-Directed Aggression	19	0.502	(0.033, 0.790)	0.028
OQS	Stranger-Directed Aggression	19	0.711	(0.327, 0.893)	0.001
F1	Stranger-Directed Aggression	19	0.510	(0.042, 0.795)	0.026
F2	Stranger-Directed Aggression	19	0.444	(-0.036, 0.758)	0.057
F3	Stranger-Directed Aggression	19	0.498	(0.027, 0.788)	0.030
MDT	Stranger-Directed Aggression	19	-0.089	(-0.523, 0.381)	0.716
Dog-Directed Aggression	Owner-Directed Aggression	19	0.340	(-0.149, 0.695)	0.154
Dog-Directed Fear	Owner-Directed Aggression	19	0.293	(-0.196, 0.665)	0.224
Familiar Dog Aggression	Owner-Directed Aggression	19	0.567	(0.115, 0.825)	0.011
Trainability	Owner-Directed Aggression	19	-0.032	(-0.480, 0.428)	0.895

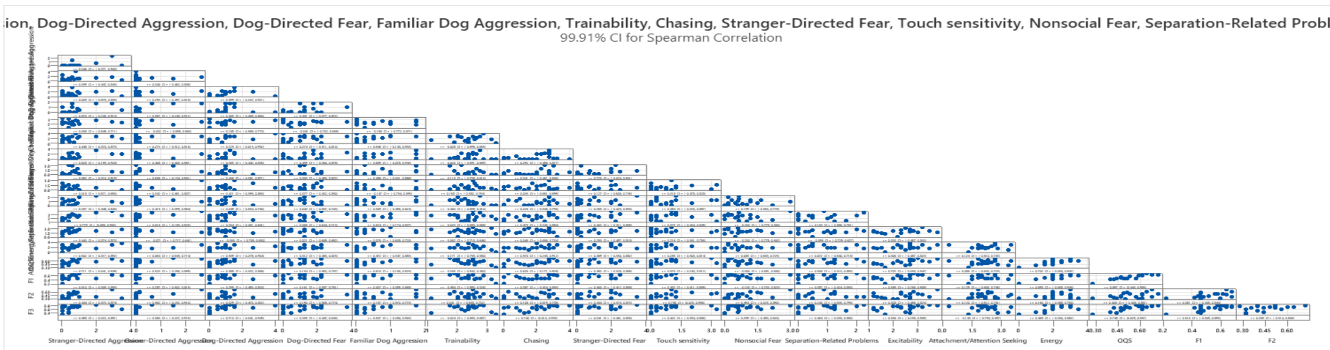
Chasing	Owner-Directed Aggression	19	0.273	(-0.215, 0.652)	0.258
Touch sensitivity	Owner-Directed Aggression	19	0.638	(0.214, 0.860)	0.003
Nonsocial Fear	Owner-Directed Aggression	19	0.342	(-0.147, 0.696)	0.152
Separation-Related Problems	Owner-Directed Aggression	19	0.416	(-0.068, 0.742)	0.076
Excitability	Owner-Directed Aggression	19	0.616	(0.182, 0.849)	0.005
Attachment/Attention Seeking	Owner-Directed Aggression	19	-0.071	(-0.509, 0.396)	0.773
Energy	Owner-Directed Aggression	19	0.064	(-0.403, 0.504)	0.795
OQS	Owner-Directed Aggression	19	0.523	(0.058, 0.801)	0.022
F1	Owner-Directed Aggression	19	0.287	(-0.202, 0.661)	0.234
F2	Owner-Directed Aggression	19	0.562	(0.108, 0.822)	0.012
F3	Owner-Directed Aggression	19	0.583	(0.136, 0.833)	0.009
MDT	Owner-Directed Aggression	19	-0.132	(-0.555, 0.344)	0.589
Dog-Directed Fear	Dog-Directed Aggression	19	0.599	(0.158, 0.841)	0.007
Familiar Dog Aggression	Dog-Directed Aggression	19	0.405	(-0.080, 0.735)	0.086
Trainability	Dog-Directed Aggression	19	0.188	(-0.295, 0.595)	0.440
Chasing	Dog-Directed Aggression	19	0.725	(0.352, 0.899)	0.000
Touch sensitivity	Dog-Directed Aggression	19	0.436	(-0.045, 0.753)	0.062
Nonsocial Fear	Dog-Directed Aggression	19	0.421	(-0.062, 0.744)	0.073
Separation-Related Problems	Dog-Directed Aggression	19	0.049	(-0.415, 0.492)	0.842
Excitability	Dog-Directed Aggression	19	0.354	(-0.134, 0.704)	0.137
Attachment/Attention Seeking	Dog-Directed Aggression	19	-0.055	(-0.497, 0.410)	0.824
Energy	Dog-Directed Aggression	19	0.539	(0.079, 0.810)	0.017
OQS	Dog-Directed Aggression	19	0.488	(0.015, 0.782)	0.034
F1	Dog-Directed Aggression	19	0.299	(-0.190, 0.669)	0.214
F2	Dog-Directed Aggression	19	0.329	(-0.160, 0.689)	0.169
F3	Dog-Directed Aggression	19	0.710	(0.327, 0.893)	0.001
MDT	Dog-Directed Aggression	19	-0.036	(-0.482, 0.425)	0.884
Familiar Dog Aggression	Dog-Directed Fear	19	0.441	(-0.040, 0.756)	0.059
Trainability	Dog-Directed Fear	19	-0.041	(-0.486, 0.422)	0.869
Chasing	Dog-Directed Fear	19	0.274	(-0.214, 0.653)	0.256
Touch sensitivity	Dog-Directed Fear	19	0.303	(-0.186, 0.672)	0.207
Nonsocial Fear	Dog-Directed Fear	19	0.377	(-0.110, 0.718)	0.112
Separation-Related Problems	Dog-Directed Fear	19	0.043	(-0.419, 0.488)	0.861
Excitability	Dog-Directed Fear	19	0.066	(-0.401, 0.505)	0.790
Attachment/Attention Seeking	Dog-Directed Fear	19	0.021	(-0.437, 0.471)	0.932
Energy	Dog-Directed Fear	19	0.312	(-0.177, 0.677)	0.194
OQS	Dog-Directed Fear	19	0.154	(-0.326, 0.570)	0.530
F1	Dog-Directed Fear	19	0.161	(-0.319, 0.575)	0.510
F2	Dog-Directed Fear	19	0.190	(-0.293, 0.596)	0.435
F3	Dog-Directed Fear	19	0.359	(-0.129, 0.707)	0.131
MDT	Dog-Directed Fear	19	-0.275	(-0.654, 0.214)	0.254
Trainability	Familiar Dog Aggression	19	-0.186	(-0.593, 0.297)	0.446
Chasing	Familiar Dog Aggression	19	0.646	(0.226, 0.864)	0.003
Touch sensitivity	Familiar Dog Aggression	19	0.488	(0.016, 0.783)	0.034
Nonsocial Fear	Familiar Dog Aggression	19	-0.147	(-0.566, 0.331)	0.547
Separation-Related Problems	Familiar Dog Aggression	19	0.309	(-0.180, 0.675)	0.198
Excitability	Familiar Dog Aggression	19	0.624	(0.194, 0.853)	0.004
Attachment/Attention Seeking	Familiar Dog Aggression	19	0.076	(-0.392, 0.513)	0.758
Energy	Familiar Dog Aggression	19	0.472	(-0.004, 0.774)	0.041
OQS	Familiar Dog Aggression	19	0.616	(0.182, 0.849)	0.005
F1	Familiar Dog Aggression	19	0.427	(-0.056, 0.748)	0.068
F2	Familiar Dog Aggression	19	0.187	(-0.296, 0.594)	0.443
F3	Familiar Dog Aggression	19	0.537	(0.076, 0.809)	0.018
MDT	Familiar Dog Aggression	19	-0.243	(-0.632, 0.245)	0.317
Chasing	Trainability	19	-0.028	(-0.477, 0.431)	0.908
Touch sensitivity	Trainability	19	-0.115	(-0.542, 0.359)	0.638
Nonsocial Fear	Trainability	19	0.168	(-0.313, 0.580)	0.491
Separation-Related Problems	Trainability	19	-0.403	(-0.734, 0.082)	0.087
Excitability	Trainability	19	-0.023	(-0.472, 0.436)	0.925
Attachment/Attention Seeking	Trainability	19	-0.062	(-0.503, 0.404)	0.800
Energy	Trainability	19	-0.171	(-0.583, 0.310)	0.483
OQS	Trainability	19	-0.355	(-0.705, 0.133)	0.136
F1	Trainability	19	-0.494	(-0.786, -0.022)	0.032
F2	Trainability	19	0.041	(-0.421, 0.487)	0.867
F3	Trainability	19	-0.024	(-0.473, 0.435)	0.921
MDT	Trainability	19	-0.108	(-0.537, 0.365)	0.659
Touch sensitivity	Chasing	19	0.341	(-0.148, 0.696)	0.154
Nonsocial Fear	Chasing	19	0.035	(-0.426, 0.482)	0.887

Separation-Related Problems	Chasing	19	0.226	(-0.260, 0.621)	0.352
Excitability	Chasing	19	0.475	(-0.001, 0.775)	0.040
Attachment/Attention Seeking	Chasing	19	0.045	(-0.418, 0.489)	0.856
Energy	Chasing	19	0.570	(0.118, 0.826)	0.011
OQS	Chasing	19	0.626	(0.197, 0.854)	0.004
F1	Chasing	19	0.387	(-0.100, 0.724)	0.102
F2	Chasing	19	0.108	(-0.365, 0.537)	0.659
F3	Chasing	19	0.740	(0.377, 0.906)	0.000
MDT	Chasing	19	-0.012	(-0.464, 0.444)	0.960
Nonsocial Fear	Touch sensitivity	19	0.318	(-0.171, 0.682)	0.184
Separation-Related Problems	Touch sensitivity	19	0.484	(0.011, 0.780)	0.036
Excitability	Touch sensitivity	19	0.375	(-0.112, 0.717)	0.114
Attachment/Attention Seeking	Touch sensitivity	19	0.216	(-0.269, 0.614)	0.374
Energy	Touch sensitivity	19	0.285	(-0.204, 0.660)	0.237
OQS	Touch sensitivity	19	0.570	(0.118, 0.826)	0.011
F1	Touch sensitivity	19	0.402	(-0.083, 0.733)	0.088
F2	Touch sensitivity	19	0.746	(0.388, 0.908)	0.000
F3	Touch sensitivity	19	0.422	(-0.061, 0.745)	0.072
MDT	Touch sensitivity	19	-0.281	(-0.657, 0.208)	0.244
Separation-Related Problems	Nonsocial Fear	19	0.199	(-0.285, 0.602)	0.415
Excitability	Nonsocial Fear	19	-0.203	(-0.605, 0.282)	0.405
Attachment/Attention Seeking	Nonsocial Fear	19	-0.200	(-0.603, 0.284)	0.412
Energy	Nonsocial Fear	19	0.085	(-0.384, 0.520)	0.728
OQS	Nonsocial Fear	19	-0.000	(-0.455, 0.454)	0.999
F1	Nonsocial Fear	19	-0.103	(-0.533, 0.370)	0.676
F2	Nonsocial Fear	19	0.494	(0.023, 0.786)	0.031
F3	Nonsocial Fear	19	0.299	(-0.190, 0.669)	0.214
MDT	Nonsocial Fear	19	-0.004	(-0.457, 0.451)	0.989
Excitability	Separation-Related Problems	19	0.163	(-0.318, 0.576)	0.506
Attachment/Attention Seeking	Separation-Related Problems	19	-0.095	(-0.528, 0.376)	0.698
Energy	Separation-Related Problems	19	0.072	(-0.395, 0.510)	0.768
OQS	Separation-Related Problems	19	0.506	(0.037, 0.792)	0.027
F1	Separation-Related Problems	19	0.387	(-0.100, 0.724)	0.102
F2	Separation-Related Problems	19	0.240	(-0.247, 0.630)	0.323
F3	Separation-Related Problems	19	0.464	(-0.014, 0.769)	0.046
MDT	Separation-Related Problems	19	-0.266	(-0.647, 0.223)	0.272
Attachment/Attention Seeking	Excitability	19	0.333	(-0.156, 0.691)	0.164
Energy	Excitability	19	0.306	(-0.183, 0.674)	0.202
OQS	Excitability	19	0.702	(0.313, 0.889)	0.001
F1	Excitability	19	0.559	(0.104, 0.820)	0.013
F2	Excitability	19	0.308	(-0.181, 0.675)	0.199
F3	Excitability	19	0.556	(0.100, 0.819)	0.013
MDT	Excitability	19	-0.061	(-0.502, 0.405)	0.803
Energy	Attachment/Attention Seeking	19	0.124	(-0.352, 0.548)	0.614
OQS	Attachment/Attention Seeking	19	0.086	(-0.384, 0.520)	0.727
F1	Attachment/Attention Seeking	19	0.129	(-0.347, 0.553)	0.597
F2	Attachment/Attention Seeking	19	0.120	(-0.355, 0.545)	0.626
F3	Attachment/Attention Seeking	19	-0.145	(-0.564, 0.334)	0.555
MDT	Attachment/Attention Seeking	19	-0.057	(-0.499, 0.408)	0.816
OQS	Energy	19	0.702	(0.313, 0.889)	0.001
F1	Energy	19	0.695	(0.301, 0.886)	0.001
F2	Energy	19	0.160	(-0.320, 0.575)	0.513
F3	Energy	19	0.469	(-0.007, 0.772)	0.043
MDT	Energy	19	0.077	(-0.392, 0.514)	0.755
F1	OQS	19	0.897	(0.706, 0.967)	0.000
F2	OQS	19	0.408	(-0.077, 0.736)	0.083
F3	OQS	19	0.748	(0.392, 0.909)	0.000
MDT	OQS	19	-0.078	(-0.514, 0.391)	0.752
F2	F1	19	0.361	(-0.127, 0.708)	0.129
F3	F1	19	0.510	(0.042, 0.795)	0.026
MDT	F1	19	-0.124	(-0.549, 0.352)	0.613
F3	F2	19	0.269	(-0.219, 0.650)	0.265
MDT	F2	19	-0.421	(-0.745, 0.062)	0.072

MDT	F3	19	0.063	(-0.403, 0.503)	0.799

MDT by C-BARQ and DIAS subscales are highlighted in yellow. Significant monotonic associations between C-BARQ and DIAS subscales are highlighted in green.

S4
Bonferroni Corrected Spearman Correlation: Stranger-Directed Aggression, Owner-Directed Aggression, Dog-Directed Aggression, Dog-Directed Fear, Familiar Dog Aggression, Trainability, Chasing, Stranger-Directed Fear, Touch sensitivity, Nonsocial Fear, Separation-Related Problems, Excitability, Attachment/Attention Seeking, Energy, OQS, F1, F2, F3



Method

Correlation type	Spearman
Number of rows used	19

ρ: pairwise Spearman correlation

Correlations

	Stranger-Directed Aggression	Owner-Directed Aggression	Dog-Directed Aggression	Dog-Directed Fear
Owner-Directed Aggression	0.546			
Dog-Directed Aggression	0.359	0.340		
Dog-Directed Fear	0.009	0.293	0.599	
Familiar Dog Aggression	0.570	0.567	0.405	0.441
Trainability	0.058	-0.032	0.188	-0.041
Chasing	0.448	0.273	0.725	0.274
Stranger-Directed Fear	0.628	0.408	0.365	0.459
Touch sensitivity	0.592	0.638	0.436	0.303
Nonsocial Fear	0.018	0.342	0.421	0.377
Separation-Related Problems	0.357	0.416	0.049	0.043
Excitability	0.779	0.616	0.354	0.066
Attachment/Attention Seeking	0.443	-0.071	-0.055	0.021
Energy	0.502	0.064	0.539	0.312
OQS	0.711	0.523	0.488	0.154
F1	0.510	0.287	0.299	0.161
F2	0.444	0.562	0.329	0.190
F3	0.498	0.583	0.710	0.359

	Familiar Dog Aggression	Trainability	Chasing	Stranger-Directed Fear	Touch sensitivity
Owner-Directed Aggression					
Dog-Directed Aggression					
Dog-Directed Fear					
Familiar Dog Aggression					
Trainability	-0.186				
Chasing	0.646	-0.028			
Stranger-Directed Fear	0.689	-0.020	0.292		
Touch sensitivity	0.488	-0.115	0.341	0.720	
Nonsocial Fear	-0.147	0.168	0.035	0.127	0.318
Separation-Related Problems	0.309	-0.403	0.226	0.385	0.484
Excitability	0.624	-0.023	0.475	0.402	0.375
Attachment/Attention Seeking	0.076	-0.062	0.045	0.293	0.216
Energy	0.472	-0.171	0.570	0.469	0.285
OQS	0.616	-0.355	0.626	0.492	0.570
F1	0.427	-0.494	0.387	0.400	0.402

F2	0.187	0.041	0.108	0.444	0.746
F3	0.537	-0.024	0.740	0.341	0.422

	Nonsocial Fear	Separation-Related Problems	Excitability	Attachment/Attention Seeking
Owner-Directed Aggression				
Dog-Directed Aggression				
Dog-Directed Fear				
Familiar Dog Aggression				
Trainability				
Chasing				
Stranger-Directed Fear				
Touch sensitivity				
Nonsocial Fear				
Separation-Related Problems	0.199			
Excitability	-0.203	0.163		
Attachment/Attention Seeking	-0.200	-0.095	0.333	
Energy	0.085	0.072	0.306	0.124
OQS	-0.000	0.506	0.702	0.086
F1	-0.103	0.387	0.559	0.129
F2	0.494	0.240	0.308	0.120
F3	0.299	0.464	0.556	-0.145

	Energy	OQS	F1	F2
Owner-Directed Aggression				
Dog-Directed Aggression				
Dog-Directed Fear				
Familiar Dog Aggression				
Trainability				
Chasing				
Stranger-Directed Fear				
Touch sensitivity				
Nonsocial Fear				
Separation-Related Problems				
Excitability				
Attachment/Attention Seeking				
Energy				
OQS	0.702			
F1	0.695	0.897		
F2	0.160	0.408	0.361	
F3	0.469	0.748	0.510	0.269

Pairwise Spearman Correlations

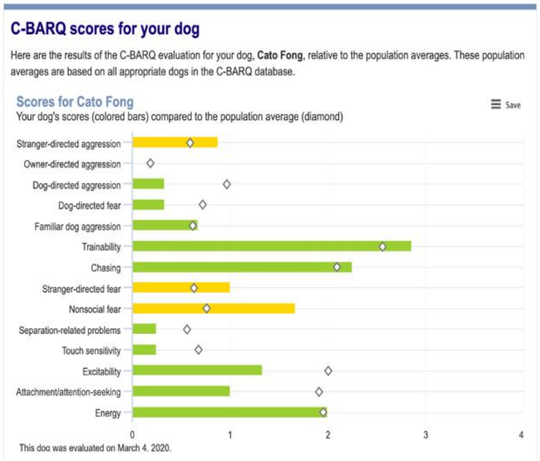
Sample 1	Sample 2	N	Correlation	99.91% CI for ρ	P-Value
Owner-Directed Aggression	Stranger-Directed Aggression	19	0.546	(-0.271, 0.905)	0.016
Dog-Directed Aggression	Stranger-Directed Aggression	19	0.359	(-0.447, 0.843)	0.132
Dog-Directed Fear	Stranger-Directed Aggression	19	0.009	(-0.676, 0.685)	0.972
Familiar Dog Aggression	Stranger-Directed Aggression	19	0.570	(-0.243, 0.913)	0.011
Trainability	Stranger-Directed Aggression	19	0.058	(-0.649, 0.711)	0.815
Chasing	Stranger-Directed Aggression	19	0.448	(-0.370, 0.875)	0.054
Stranger-Directed Fear	Stranger-Directed Aggression	19	0.628	(-0.169, 0.928)	0.004
Touch sensitivity	Stranger-Directed Aggression	19	0.592	(-0.216, 0.919)	0.008
Nonsocial Fear	Stranger-Directed Aggression	19	0.018	(-0.671, 0.690)	0.942
Separation-Related Problems	Stranger-Directed Aggression	19	0.357	(-0.448, 0.843)	0.133
Excitability	Stranger-Directed Aggression	19	0.779	(0.096, 0.963)	0.000
Attachment/Attention Seeking	Stranger-Directed Aggression	19	0.443	(-0.374, 0.873)	0.057
Energy	Stranger-Directed Aggression	19	0.502	(-0.317, 0.892)	0.028
OQS	Stranger-Directed Aggression	19	0.711	(-0.041, 0.949)	0.001
F1	Stranger-Directed Aggression	19	0.510	(-0.309, 0.895)	0.026
F2	Stranger-Directed Aggression	19	0.444	(-0.373, 0.874)	0.057
F3	Stranger-Directed Aggression	19	0.498	(-0.322, 0.891)	0.030
Dog-Directed Aggression	Owner-Directed Aggression	19	0.340	(-0.462, 0.836)	0.154
Dog-Directed Fear	Owner-Directed Aggression	19	0.293	(-0.497, 0.818)	0.224
Familiar Dog Aggression	Owner-Directed Aggression	19	0.567	(-0.245, 0.912)	0.011
Trainability	Owner-Directed Aggression	19	-0.032	(-0.698, 0.663)	0.895
Chasing	Owner-Directed Aggression	19	0.273	(-0.512, 0.810)	0.258
Stranger-Directed Fear	Owner-Directed Aggression	19	0.408	(-0.406, 0.861)	0.083
Touch sensitivity	Owner-Directed Aggression	19	0.638	(-0.154, 0.931)	0.003
Nonsocial Fear	Owner-Directed Aggression	19	0.342	(-0.461, 0.837)	0.152
Separation-Related Problems	Owner-Directed Aggression	19	0.416	(-0.399, 0.864)	0.076
Excitability	Owner-Directed Aggression	19	0.616	(-0.185, 0.925)	0.005

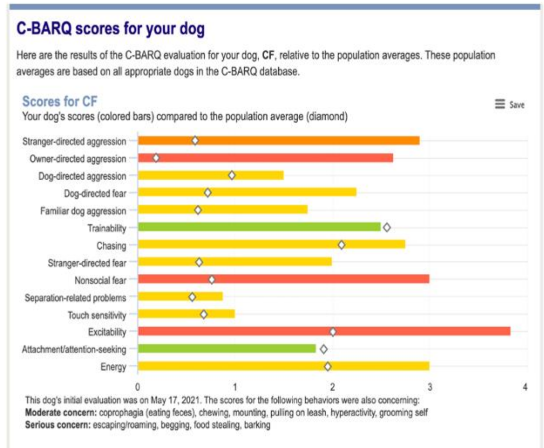
Attachment/Attention Seeking	Owner-Directed Aggression	19	-0.071	(-0.717, 0.641)	0.773
Energy	Owner-Directed Aggression	19	0.064	(-0.645, 0.714)	0.795
OQS	Owner-Directed Aggression	19	0.523	(-0.296, 0.899)	0.022
F1	Owner-Directed Aggression	19	0.287	(-0.502, 0.815)	0.234
F2	Owner-Directed Aggression	19	0.562	(-0.252, 0.910)	0.012
F3	Owner-Directed Aggression	19	0.583	(-0.227, 0.916)	0.009
Dog-Directed Fear	Dog-Directed Aggression	19	0.599	(-0.207, 0.921)	0.007
Familiar Dog Aggression	Dog-Directed Aggression	19	0.405	(-0.409, 0.860)	0.086
Trainability	Dog-Directed Aggression	19	0.188	(-0.569, 0.773)	0.440
Chasing	Dog-Directed Aggression	19	0.725	(-0.015, 0.952)	0.000
Stranger-Directed Fear	Dog-Directed Aggression	19	0.365	(-0.442, 0.845)	0.125
Touch sensitivity	Dog-Directed Aggression	19	0.436	(-0.381, 0.871)	0.062
Nonsocial Fear	Dog-Directed Aggression	19	0.421	(-0.395, 0.865)	0.073
Separation-Related Problems	Dog-Directed Aggression	19	0.049	(-0.654, 0.706)	0.842
Excitability	Dog-Directed Aggression	19	0.354	(-0.451, 0.841)	0.137
Attachment/Attention Seeking	Dog-Directed Aggression	19	-0.055	(-0.709, 0.650)	0.824
Energy	Dog-Directed Aggression	19	0.539	(-0.278, 0.904)	0.017
OQS	Dog-Directed Aggression	19	0.488	(-0.332, 0.888)	0.034
F1	Dog-Directed Aggression	19	0.299	(-0.493, 0.820)	0.214
F2	Dog-Directed Aggression	19	0.329	(-0.470, 0.832)	0.169
F3	Dog-Directed Aggression	19	0.710	(-0.041, 0.949)	0.001
Familiar Dog Aggression	Dog-Directed Fear	19	0.441	(-0.377, 0.872)	0.059
Trainability	Dog-Directed Fear	19	-0.041	(-0.702, 0.658)	0.869
Chasing	Dog-Directed Fear	19	0.274	(-0.511, 0.810)	0.256
Stranger-Directed Fear	Dog-Directed Fear	19	0.459	(-0.360, 0.878)	0.048
Touch sensitivity	Dog-Directed Fear	19	0.303	(-0.490, 0.822)	0.207
Nonsocial Fear	Dog-Directed Fear	19	0.377	(-0.432, 0.850)	0.112
Separation-Related Problems	Dog-Directed Fear	19	0.043	(-0.657, 0.703)	0.861
Excitability	Dog-Directed Fear	19	0.066	(-0.644, 0.715)	0.790
Attachment/Attention Seeking	Dog-Directed Fear	19	0.021	(-0.669, 0.692)	0.932
Energy	Dog-Directed Fear	19	0.312	(-0.483, 0.825)	0.194
OQS	Dog-Directed Fear	19	0.154	(-0.592, 0.757)	0.530
F1	Dog-Directed Fear	19	0.161	(-0.587, 0.761)	0.510
F2	Dog-Directed Fear	19	0.190	(-0.568, 0.774)	0.435
F3	Dog-Directed Fear	19	0.359	(-0.447, 0.843)	0.131
Trainability	Familiar Dog Aggression	19	-0.186	(-0.772, 0.571)	0.446
Chasing	Familiar Dog Aggression	19	0.646	(-0.143, 0.933)	0.003
Stranger-Directed Fear	Familiar Dog Aggression	19	0.689	(-0.078, 0.943)	0.001
Touch sensitivity	Familiar Dog Aggression	19	0.488	(-0.331, 0.888)	0.034
Nonsocial Fear	Familiar Dog Aggression	19	-0.147	(-0.754, 0.595)	0.547
Separation-Related Problems	Familiar Dog Aggression	19	0.309	(-0.486, 0.824)	0.198
Excitability	Familiar Dog Aggression	19	0.624	(-0.174, 0.927)	0.004
Attachment/Attention Seeking	Familiar Dog Aggression	19	0.076	(-0.638, 0.720)	0.758
Energy	Familiar Dog Aggression	19	0.472	(-0.347, 0.883)	0.041
OQS	Familiar Dog Aggression	19	0.616	(-0.185, 0.925)	0.005
F1	Familiar Dog Aggression	19	0.427	(-0.389, 0.868)	0.068
F2	Familiar Dog Aggression	19	0.187	(-0.570, 0.773)	0.443
F3	Familiar Dog Aggression	19	0.537	(-0.280, 0.903)	0.018
Chasing	Trainability	19	-0.028	(-0.696, 0.665)	0.908
Stranger-Directed Fear	Trainability	19	-0.020	(-0.691, 0.669)	0.934
Touch sensitivity	Trainability	19	-0.115	(-0.739, 0.615)	0.638
Nonsocial Fear	Trainability	19	0.168	(-0.582, 0.764)	0.491
Separation-Related Problems	Trainability	19	-0.403	(-0.859, 0.410)	0.087
Excitability	Trainability	19	-0.023	(-0.693, 0.668)	0.925
Attachment/Attention Seeking	Trainability	19	-0.062	(-0.713, 0.646)	0.800
Energy	Trainability	19	-0.171	(-0.765, 0.580)	0.483
OQS	Trainability	19	-0.355	(-0.842, 0.450)	0.136
F1	Trainability	19	-0.494	(-0.890, 0.326)	0.032
F2	Trainability	19	0.041	(-0.658, 0.702)	0.867
F3	Trainability	19	-0.024	(-0.693, 0.667)	0.921
Stranger-Directed Fear	Chasing	19	0.292	(-0.498, 0.817)	0.225
Touch sensitivity	Chasing	19	0.341	(-0.461, 0.836)	0.154
Nonsocial Fear	Chasing	19	0.035	(-0.661, 0.699)	0.887
Separation-Related Problems	Chasing	19	0.226	(-0.545, 0.790)	0.352
Excitability	Chasing	19	0.475	(-0.345, 0.884)	0.040
Attachment/Attention Seeking	Chasing	19	0.045	(-0.656, 0.704)	0.856
Energy	Chasing	19	0.570	(-0.243, 0.912)	0.011

OQS	Chasing	19	0.626	(-0.171, 0.928)	0.004
F1	Chasing	19	0.387	(-0.424, 0.853)	0.102
F2	Chasing	19	0.108	(-0.619, 0.736)	0.659
F3	Chasing	19	0.740	(0.013, 0.955)	0.000
Touch sensitivity	Stranger-Directed Fear	19	0.720	(-0.024, 0.951)	0.001
Nonsocial Fear	Stranger-Directed Fear	19	0.127	(-0.608, 0.745)	0.605
Separation-Related Problems	Stranger-Directed Fear	19	0.385	(-0.425, 0.853)	0.103
Excitability	Stranger-Directed Fear	19	0.402	(-0.411, 0.859)	0.088
Attachment/Attention Seeking	Stranger-Directed Fear	19	0.293	(-0.497, 0.818)	0.223
Energy	Stranger-Directed Fear	19	0.469	(-0.350, 0.882)	0.043
OQS	Stranger-Directed Fear	19	0.492	(-0.328, 0.889)	0.032
F1	Stranger-Directed Fear	19	0.400	(-0.412, 0.858)	0.089
F2	Stranger-Directed Fear	19	0.444	(-0.374, 0.873)	0.057
F3	Stranger-Directed Fear	19	0.341	(-0.461, 0.836)	0.154
Nonsocial Fear	Touch sensitivity	19	0.318	(-0.478, 0.828)	0.184
Separation-Related Problems	Touch sensitivity	19	0.484	(-0.335, 0.887)	0.036
Excitability	Touch sensitivity	19	0.375	(-0.434, 0.849)	0.114
Attachment/Attention Seeking	Touch sensitivity	19	0.216	(-0.551, 0.785)	0.374
Energy	Touch sensitivity	19	0.285	(-0.503, 0.814)	0.237
OQS	Touch sensitivity	19	0.570	(-0.243, 0.912)	0.011
F1	Touch sensitivity	19	0.402	(-0.411, 0.859)	0.088
F2	Touch sensitivity	19	0.746	(0.025, 0.956)	0.000
F3	Touch sensitivity	19	0.422	(-0.394, 0.866)	0.072
Separation-Related Problems	Nonsocial Fear	19	0.199	(-0.563, 0.778)	0.415
Excitability	Nonsocial Fear	19	-0.203	(-0.779, 0.560)	0.405
Attachment/Attention Seeking	Nonsocial Fear	19	-0.200	(-0.778, 0.562)	0.412
Energy	Nonsocial Fear	19	0.085	(-0.633, 0.725)	0.728
OQS	Nonsocial Fear	19	-0.000	(-0.681, 0.680)	0.999
F1	Nonsocial Fear	19	-0.103	(-0.733, 0.623)	0.676
F2	Nonsocial Fear	19	0.494	(-0.325, 0.890)	0.031
F3	Nonsocial Fear	19	0.299	(-0.493, 0.820)	0.214
Excitability	Separation-Related Problems	19	0.163	(-0.586, 0.761)	0.506
Attachment/Attention Seeking	Separation-Related Problems	19	-0.095	(-0.729, 0.627)	0.698
Energy	Separation-Related Problems	19	0.072	(-0.640, 0.718)	0.768
OQS	Separation-Related Problems	19	0.506	(-0.313, 0.893)	0.027
F1	Separation-Related Problems	19	0.387	(-0.424, 0.853)	0.102
F2	Separation-Related Problems	19	0.240	(-0.535, 0.795)	0.323
F3	Separation-Related Problems	19	0.464	(-0.355, 0.880)	0.046
Attachment/Attention Seeking	Excitability	19	0.333	(-0.467, 0.833)	0.164
Energy	Excitability	19	0.306	(-0.487, 0.823)	0.202
OQS	Excitability	19	0.702	(-0.055, 0.947)	0.001
F1	Excitability	19	0.559	(-0.256, 0.909)	0.013
F2	Excitability	19	0.308	(-0.486, 0.824)	0.199
F3	Excitability	19	0.556	(-0.259, 0.909)	0.013
Energy	Attachment/Attention Seeking	19	0.124	(-0.610, 0.743)	0.614
OQS	Attachment/Attention Seeking	19	0.086	(-0.633, 0.725)	0.727
F1	Attachment/Attention Seeking	19	0.129	(-0.606, 0.746)	0.597
F2	Attachment/Attention Seeking	19	0.120	(-0.612, 0.741)	0.626
F3	Attachment/Attention Seeking	19	-0.145	(-0.753, 0.597)	0.555
OQS	Energy	19	0.702	(-0.055, 0.947)	0.001
F1	Energy	19	0.695	(-0.068, 0.945)	0.001
F2	Energy	19	0.160	(-0.588, 0.760)	0.513
F3	Energy	19	0.469	(-0.350, 0.882)	0.043
F1	OQS	19	0.897	(0.443, 0.985)	0.000
F2	OQS	19	0.408	(-0.406, 0.861)	0.083
F3	OQS	19	0.748	(0.029, 0.957)	0.000
F2	F1	19	0.361	(-0.445, 0.844)	0.129
F3	F1	19	0.510	(-0.309, 0.895)	0.026
F3	F2	19	0.269	(-0.514, 0.808)	0.265

S5

C-BARQ Scores from two different family members for Cato.





S6

Mann-Whitney Maximum Distance Traveled versus Bodyweight

1= < 47 pounds, 2 = > 47 pounds

Method

η_1: median of 1
η_2: median of 2
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
1	11	150
2	9	200

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-70	(-130, 0.0000000)	95.18%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	90.50	0.063
Adjusted for ties	90.50	0.061

S7

Mann-Whitney Maximum Distance Traveled versus Sex

1 = Males, 2 = Females

Method

η_1: median of 1
η_2: median of 2
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
1	12	200
2	8	165

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
30	(-70, 120)	95.09%

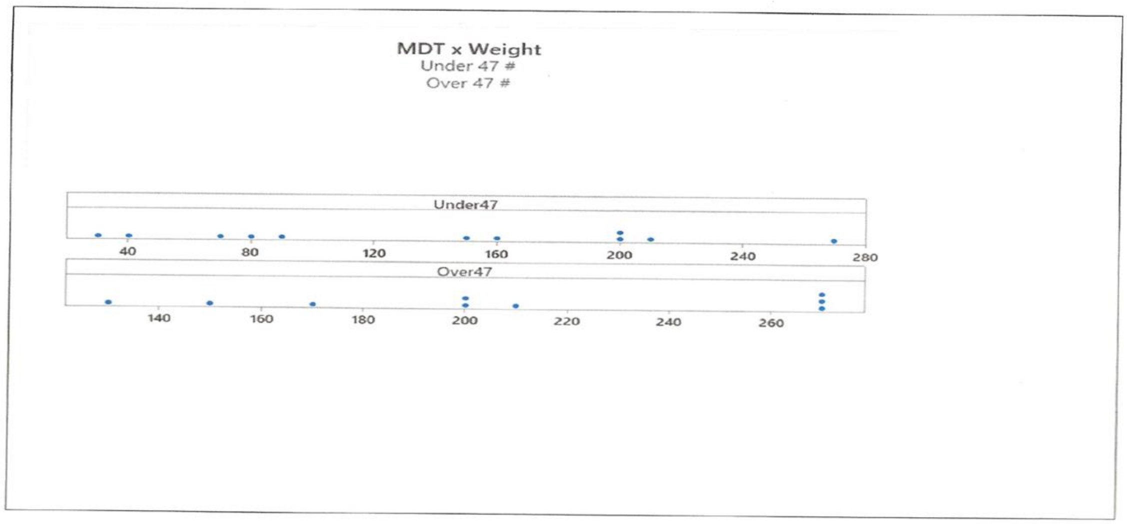
Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	134.50	0.537
Adjusted for ties	134.50	0.534

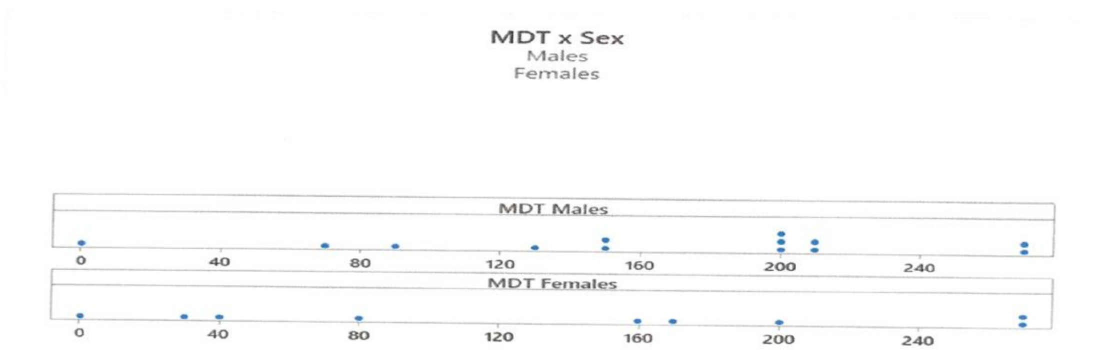
S8

Figure 16. MDT versus Bodyweight Scatterplot



S9

Figure 17. MDT versus Sex Scatterplot



S10 Electrode Safety Data Sheet

PARKER LABORATORIES, INC.

SAFETY DATA SHEET

Product Name: SPECTRA® 360 ELECTRODE GEL

US Department of Labor
Occupational
Safety and Health Administration

SECTION 1 — CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: (As used on label and List)	SPECTRA® 360 ELECTRODE GEL
Manufacturer's Name:	PARKER LABORATORIES INC.
Address:	286 ELDRIDGE ROAD
(number, street, City, State, Zip code)	FAIRFIELD, NJ 07004 USA
Emergency Telephone Number:	(800)-631-8888
Telephone Number for Information:	(973)-276-9500 (8:30am – 5:15pm ET)

SECTION 2 — HAZARDS IDENTIFICATION

Hazardous Components (Specific Chemical Identity; Common Name(s)): NONE

Classification of the Substance/Mixture: NOT CLASSIFIED

Signal Word: N/A

Hazard Statements: NO KNOWN SIGNIFICANT EFFECTS OR CRITICAL HAZARDS

Precautionary Statement: HANDLE IN ACCORDANCE WITH GOOD INDUSTRIAL HYGIENE PRACTICES

OSHA Hazards: NO OSHA HAZARDS

SECTION 3 — COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous Ingredients (specific)	% Composition	CAS Number
N/A	N/A	N/A

SECTION 4 — FIRST AID MEASURES

Signs and Symptoms of Exposure: N/A

Medical Symptoms Generally Aggravated by Exposure: NONE KNOWN

Emergency and First Aid Procedures:

Inhalation: Move to fresh air immediately. If experiencing difficulty breathing, seek medical attention.

Skin contact: In the case of skin irritation or allergic reactions, wash with soap and plenty of water. See a physician.

Eye contact: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

Ingestion: If accidentally swallowed obtain immediate medical attention.
Clean mouth with water and drink afterwards plenty of water.
Do not induce vomiting without medical advice.
Never give anything by mouth to an unconscious person.

SECTION 5 — FIRE FIGHTING MEASURES

Flash Point(Method Used): NON-FLAMABLE **Flammable Limits:** N/A **LEL:** N/A **UEL:** N/A

Extinguishing Media: USE EXTINGUISHING MEDIA APPROPRIATE FOR SORROUNDING FIRE

Special Fire Fighting Procedures: NONE

Unusual Fire and Explosion Hazards: NONE

Protective Equipment and Precautions for Firefighters: WEAR A SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE GEAR.

SECTION 6— ACCIDENTAL RELEASE MEASURES

Leak and Spill Procedures:	SLIPPERY IF SPILLED ON FLOOR. MIX WITH SWEEPING COMPOUND. MOP AREA WITH WATER.
Personal Precautions:	N/A
Environmental Precautions:	N/A

SECTION 7— HANDLING AND STORAGE

Handling procedures and Equipment: N/A

Storage requirements: NO SPECIAL PRECAUTIONS REQUIRED.

SECTION 8— EXPOSURE CONTROL/PERSONAL PROTECTION

Exposure Limits: ☐ ACGIH TLV ☐ OSHA PEL ☐ Other(Specify)

Specific Engineering Controls (such as ventilation, enclosed process) ENSURE ADEQUATE VENTILATION

Personal Protective Equipment:
☐ Gloves ☐Eye ☐Clothing ☐ Footwear ☐Respirator ☐ Other (specify)

If checked, please specify type:

SECTION 9— PHYSICAL AND CHEMICAL PROPERTIES

Physical State(Appearance):	Viscous, Clear Aqueous Gel
Color:	Blue-Green
Odor:	None
Specific Gravity(H_2O=1):	1.01
pH:	6.30-7.00
Solubility in Water:	Soluble in water
Boiling point:	N/D
Melting Point:	N/D
Flammability(solid, gas):	N/D

Vapor Pressure(mm Hg):	N/D
Vapor Density(AIR=1):	N/D
Viscosity:	175,000-260,000cps
Density:	N/D
Evaporation Rate(Butyl Acetate= 1):	N/D

SECTION 10 — STABILITY AND REACTIVITY

Stability: **Unstable** ☐ **Conditions to Avoid:** NONE

Stable ☒

Hazardous Decomposition or Byproducts: NONE

Incompatibility (Materials to Avoid): NONE

Hazardous Polymerization: May Occur? ☐ Will Not Occur? ☒

Conditions to Avoid: NONE

Reactivity: NO SPECIFIC TEST DATA RELATED TO REACTIVITY AVAILABLE FOR THIS PRODUCT.

SECTION 11 — TOXICOLOGICAL INFORMATION

Health Hazards (Acute and Chronic): NONE KNOWN

Route(s) of Entry: ☐Skin Contact ☐ Eye Contact ☐ Inhalation ☒ Ingestion

Carcinogenicity: **NTP?** NO **IARC Monographs?** NO **OSHA Regulated:** NO

Signs and Symptoms of Exposure: N/A

Medical Conditions Generally Aggravated by Exposure: NONE KNOWN

SECTION 12 — ECOLOGICAL INFORMATION

Ecotoxicity:	N/A
Persistence and Degradability	THERE IS NO DATA AVAILABLE FOR THIS PRODUCT
Bioaccumulative Potential	THERE IS NO DATA AVAILABLE FOR THIS PRODUCT
Mobility in the Soil:	THERE IS NO DATA AVAILABLE FOR THIS PRODUCT
Additional Ecological Information:	THERE IS NO DATA AVAILABLE FOR THIS PRODUCT

SECTION 13 — DISPOSAL CONSIDERATIONS

Waste Disposal:

FOLLOW ALL FEDERAL, STATE AND LOCAL REGULATIONS FOR NON-HAZARDOUS WASTE DISPOSAL.

SECTION 14 — TRANSPORT INFORMATION

DOT Classification:	NOT REGULATED
IMDG Classification:	NOT REGULATED
TDG Classification:	NOT REGULATED
IATA Classification:	NOT REGULATED
RID:	NOT REGULATED

SECTION 15 — REGULATORY INFORMATION

OSHA Hazards:	NO OSHA HAZARDS
SARA 311/312 Hazards:	NO SARA HAZARDS

SECTION 16 — OTHER INFORMATION

Date of Issue:	**5/28/2015**
Prepared By:	**Quality Assurance**
Version:	1

Disclaimer: *This information is based on our current knowledge and is intended to describe the product for the purposes of health, safety and environmental requirements only. No warranty, guarantee or representation is made as to the correctness and sufficiency of the information. It's the user's responsibility to determine safe conditions for the use of this product and to assume liability for loss, injury, or expense resulting from the misuse of this product.*

S11 Consent Form

Pharr Road Animal Hospital

***and* University of Pennsylvania School of Veterinary Medicine**

Master of Science in Animal Welfare and Behavior

Owner Informed Consent Form

Protocol Title:
Master of Science (MSc) in Animal Welfare and Behavior: Capstone Project
"Canine Impulsivity, as measured by C-BARQ and DIAS Scores Are Inversely Related to Maximum Distance Traveled in a Spatial Discounting Test and to Heart Rate Variability"

Why am I being asked to volunteer my pet?

You are being invited to have your pet participate in a research study regarding impulsivity in companion dogs.

Before you can make your decision, you will need to know what the study is about, the possible risks and benefits of your pet being in this study, and what you will have to do in this study.

What is the purpose of this research study?

The purpose of this study is to evaluate methods to identify impulsive dogs. Impulsivity is action without forethought and lack of consideration about the consequences of that action.

What am I being asked to do?

You and your dog will participate in:

1. Two personality surveys, the C-BARQ and the DIAS. These two questionnaires should each take approximately 20- 25 minutes to complete.
2. A behavior test at PRAH that measures your dog's ability to delay access to a food reward.
3. Three heart rate recordings; two at PRAH and one at your home during a Zoom meeting with Dr. Sasher.
4. Tests 2 and 3 will take approximately 2 ½ hours at PRAH and the heart rate recording during a Zoom session should take about 30 minutes.

Your dog is eligible to participate in this trial if:

1. They are not currently taking any prescription medications for any behavioral diagnosis.

2. They have no underlying orthopedic diagnosis that would inhibit their mobility during the behavior test.

What are the possible risks or discomforts to my pet?

No invasive or painful procedures will occur during the study. Any food allergies should be discussed prior to testing to ensure that appropriate rewards will be selected for use. A veterinarian will perform all dog handling procedures and participant education for the at-home heart rate recording. All sessions will be recorded. Owners will not be present during the behavior test.

What are the possible benefits of the study for my pet?

You will learn more about your dog! Are they a "thinker or a doer"? Understanding this information about your dog will help you train them. By participating in this research project you will also be helping other dogs. What we learn will be particularly helpful for shelter and rescue dogs by providing information to help determine whether they are thinkers or doers. We will use that information to customize training programs.

What happens if my pet is injured or hurt during the study?

I do not anticipate any medical emergencies during the testing at PRAH or at your home.

If your pet has a medical emergency during the study, you may seek treatment at PRAH or go to the nearest emergency clinic of your choice.

If you believe that your pet is hurt or injured because of participation in this research study, please contact the investigators listed on the last page of this form.

Pharr Road Animal Hospital, its agents, and employees have no responsibility in this study. PRAH, their agents, and owners assume no risk or liability to any dog or person volunteering to participate in this study.

Who can see or use my and my pet's information?

Your name and email will not be made public. Your dog will be identified by first name, age, gender, and breed. I will use the study data collected to complete my PennVet Animal Welfare and Behavior Master's thesis requirement. I intend to publish the data in a scientific journal.

Who can I call with questions, complaints or if I'm concerned about this research?

If you have questions, concerns, or complaints regarding your pet's participation in this research study, you should speak first with me. My contact information is on the last page. You may also contact the Principal Investigators who are also listed.

When you sign this form, you are agreeing to have your pet take part in this research study. This means that you have read the consent form, your questions have been answered, and you have decided to volunteer your pet. Your signature also means that you agree that Pharr Road Animal Hospital assumes no risk or liability to any dog or person volunteering to participate in this study. Your signature also confirms that you are over 18 years of age and the legal owner or authorized agent of this pet. A copy of this consent form will be given to you. You can withdraw from this study at any time with no penalty.

Thank you for supporting my research project - I could not complete this study without your help.

Pet's Name: ______________________________

Owner's Name: ______________________________

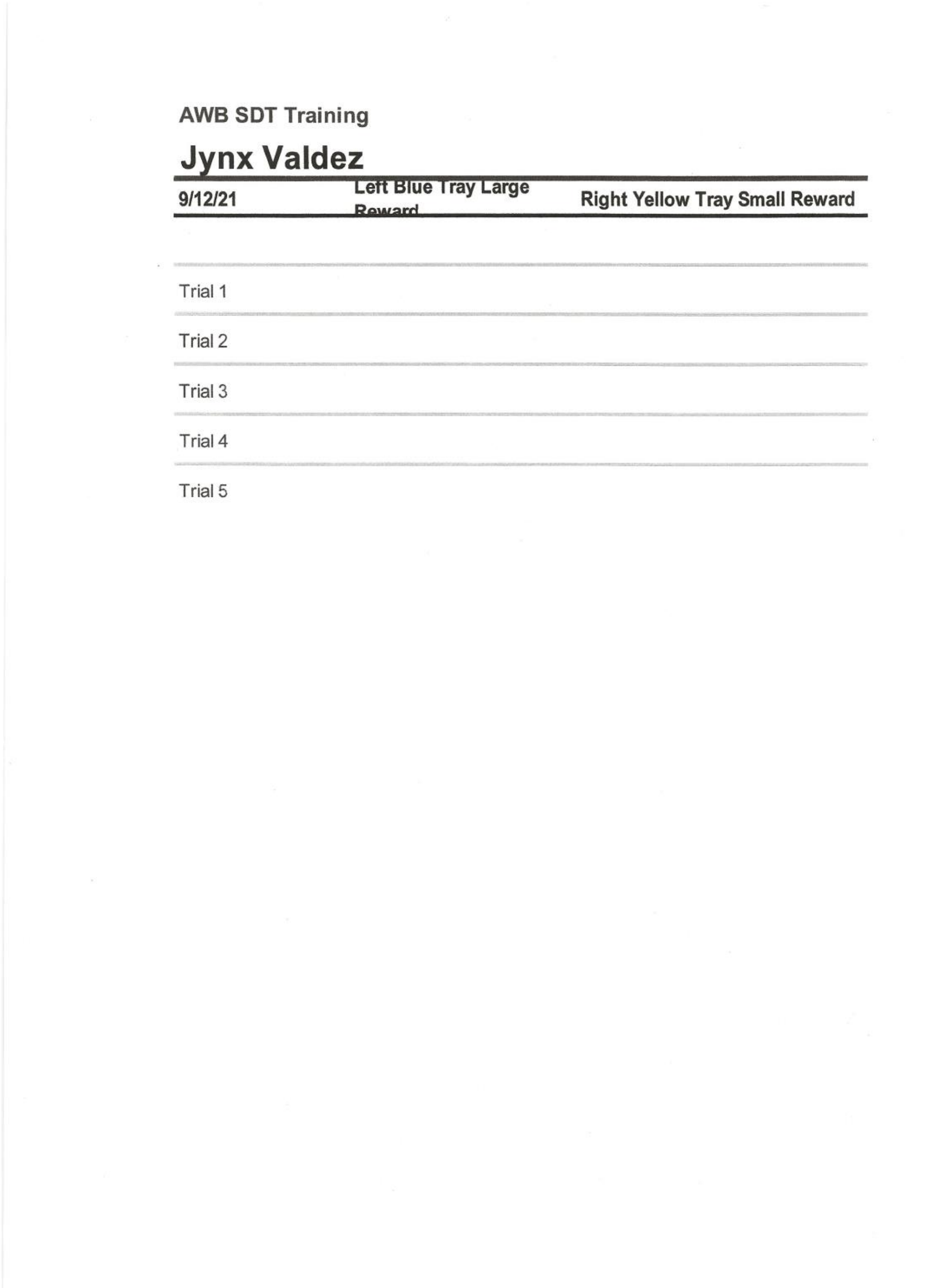
Owner's Signature: ______________________________

Date: ______________

Investigator (Dr. Sasher) Signature: ______________________________

Date: ______________

S12 Spatial Discounting Training Log Form



AWB SDT Training

Jynx Valdez

9/12/21	Left Blue Tray Large Reward	Right Yellow Tray Small Reward
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		

S13 Spatial Discounting Testing Log Form Example

9/12/21		
SDT		
Koda Haight		
9/12/21	**Left Blue Tray Small Reward**	**Right Yellow Tray Large Reward**
Start Line		
10 inch		
20 Inch		
30 inch		
40 inch		
50 inch		
60 inch		
70 inch		
80 inch		
90 inch		
100 inch		
110 inch		
120 inch		
130 inch		
140 inch		
150 inch		
160 inch		
170 inch		
180 inch		

	9/12/21	Left Blue Tray Small Reward	Right Yellow Tray Large Reward
	190 inmch		
	200 inch		
	210 inch		
	220 inch		
	230 inch		
	240 inch		
	250 inch		
	260 inch		
	270 inch		
	280 inch		
	290 inch		
	300 inch		
	Finish		

Page 2 of 2