Understanding the Impacts of Breed Identity, Post-Adoption and Fostering Interventions, & Behavioral Welfare of Shelter Dogs

by

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ABSTRACT

Each year, nearly three million dogs will enter one of over 13,000 animal shelters in the United States. The purpose of this dissertation is to better understand how breed identity and dog welfare in the shelter, in addition to post-adoption and fostering interventions out of the shelter, can contribute to the betterment of dog lives. In Chapter 2, I conducted the largest sampling of shelter dogs' breed identities to-date to determine their breed heritage and compare shelter breed assignment by staff as determined by visual appearance to that of genetic testing. In Chapter 4, I examined the efficacy of a post-adoption intervention intended to reduce returns by encouraging physical activity between adopters and their dogs. In Chapter 6, I examined the effects of brief stays in a foster home on the urinary cortisol: creatinine ratios of dogs awaiting adoption compared to ratios collected before or after their stays; and in Chapter 7, I characterized the relationships between multiple physiological, health, and cognitive measures and the in-kennel behavior of shelter dogs.

Four suggestions from the findings of this dissertation that will likely better the lives of dogs living in animal shelters are: 1) Shelter dog breed heritage is complex and visually identifying multiple breeds in a mixed breed dog is difficult at best. Shelters should instead focus on communicating the morphology and behavior of the dogs in their care to best support adopters. 2) While encouraging walking did not influence owner behavior, adopters who reported higher obligation and self-efficacy in dog walking were more active with their dogs. Thus, post-adoption interventions that can effectively target owner perceptions of obligation and self-efficacy may be more successful in changing behavior. 3) Temporary fostering is an impactful intervention that reduces stress for dogs

awaiting adoption; however addressing stressors present at shelters that are likely contributing to higher stress responding is also needed. 4) It is possible to predict the internal stress responding of shelter dogs by observing their overt, in-kennel behavior, and this study is a first step in assessing and improving the welfare of dogs living in animal shelters.

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CHAPTER 1

REVIEW OF WHO ARE THE DOGS ARE THAT ENTER ANIMAL SHELTERS

In this chapter, I will review our current knowledge about the dogs that arrive to animal shelters in the United States and around the world. By understanding the characteristics of these dogs, we can identify areas where more data collection and analysis is needed to inform animal sheltering practices.

The American Society for the Prevention of Cruelty to Animals (ASPCA) estimates that over 13,000 animal shelters operate in the United States (ASPCA, 2016). This year, over 3 million dogs will enter one of these shelters (ASPCA, 2018). Recent survey data from the American Pet Products Association (APPA) indicate that 55 million homes in the United States have a dog, with 78 million dogs living in human households (APPA, 2016), approximately 20% of whom were adopted from shelters (Maddalena, Zeidman, & Campbell, 2012). The number of dogs living in the US is comparable to the count in Europe, where more than 80 million dogs live in over 20% of the region's households (European Pet Food Industry, 2014). The percentage of the United States population that is dog-owning has shown modest growth (36-44%) over the past fifteen years (Scarlett, 2013; APPA, 2016).

Dogs may arrive at the animal shelter in one of four ways: 1) surrendered by their owners; 2) as strays; 3) returned to the shelter after adoption; or, 4) confiscated as part of cruelty and criminal cases. Results from the National Council on Pet Population Study & Policy's survey of 4,700 United States shelters from 1994-1995 indicate that close to

30% of dogs that entered shelters did so as owner-surrenders (Zawistowski, Morris, Salman, & Ruch-Gallie, 1998). This complements more recent statistics from the ASPCA which find twice as many dogs enter shelters as strays rather than as relinquishments by their owner (ASPCA, 2018).

However, findings from a 2010 census from the United Kingdom suggest that the number of owner-surrendered dogs may be nearer to 50% of that country's shelter dogs (Stavisky, Brennan, Downes, & Dean, 2012), while in Australia that number is only 15% (Marston, Bennett, & Coleman, 2004). A majority of owner-surrendered dogs in the United States are young, intact and not purebred (New, Salman, King, Scarlett, Kass, & Hutchison, 2000). Patronek, Beck, and Glickman (1997) reported that dogs relinquished to a shelter in Indiana accounted for nearly 4% of the canine population in the community and they noted that owners likely under-reported surrendering their pets when questioned.

Dogs entering shelters as strays compose 53-83% of shelter canine populations (Wenstrup & Dowidchuk, 1999; Lepper, Kass, & Hart, 2002; Protopopova, Gilmour, Weiss, Shen, & Wynne, 2012). In a 2009 study investigating microchip prevalence in United States animal shelters, 58% of microchipped dogs arrived as strays. Of those dogs, 52% were returned to their owners, compared to just 22% of the shelters' total stray dog population who were reunited with their owners (Lord, Ingwersen, Gray, & Wintz. 2009). Overall, dogs that come into shelters but then are reunited with their owners make up 13-23% the shelter dog population, with older dogs having higher rates of return than those less than six months of age (Zawistowski et al., 1998; Wenstrup & Dowidchuk, 1999; Bartlett, Bartlett, Walshaw, & Halstead, 2005). Calculations about the number of dogs returned to owners, however, are often based on total dogs received at the shelter and not solely on stray intakes.

A small portion of dogs in animal shelters are confiscated from owners due to abuse or neglect (McMillan, Duffy, Zawistowski, & Serpell, 2015). Such cases are uncommon and thus it is difficult to determine prevalence on a national scale, as they are often included in multi-use ("other") categories that do not provide for a detailed breakdown. From regional studies, Protopopova et al. (2012) concluded that confiscated dogs comprised approximately 10% of the shelter dog population at a Florida municipal shelter. A collective confiscate percentage at four shelters in Massachusetts over a two-and-a-half year period was just 3% (Dowling-Guyer, Marder, & D'Arpino, 2011) while dogs held under legal order in Australia made up only 1% of admissions (Marston et al., 2004).

The majority of dogs living in animal shelters are under two-years-old (Patronek, Glickman, & Moyer, 1995; Bollen & Horowitz 2008; Protopopova, Mehrkam, Boggess, & Wynne, 2014; Barnard, Chincarini, Di Tommaso, Di Giulio, Messori, & Ferri, 2015), although their exact ages are often difficult to determine. In attempting to understand shelter dog populations, researchers have often identified the prevalence of certain breeds in these facilities as it's often implicated as an influencing factor in adoption success (Posage, Bartlett, & Thomas, 1996; Lepper et al., 2002; Diesel, Smith, & Pfeiffer, 2007). However, breed assignment performed at animal shelters is often based on visual appearance; and this method has been found to be an inconsistent and unreliable means of identification (Voith, Ingram, Mitsouras, & Irizarry, 2009; Olson et al., 2015).

Furthermore, Gunter, Barber, and Wynne (2016) found that the breed label on the kennel card can have a large impact on adoption.

Instead, genetic canine heritage testing may more accurately describe the breeds present in today's shelter dogs and allow us to better infer the influence of breed on outcomes, however the majority of shelter dogs may be mixed breed with only a small percentage of purebreds (Barnard et al., 2015). In a study of over nearly 1000 shelter dogs at two US shelters using the MARS Wisdom Panel, less than 5% of dogs were purebreds and the majority of dogs were mixes of more than two breeds. While dogs having a pit bull-type and Chihuahua breed signature comprised roughly 50% of the population at both shelters, the remaining dogs consisted solely of other breeds. In total, over 100 breeds were identified (Gunter, Barber, & Wynne, under review). Yet while reliable behavioral differences between dog breeds do exist, there is also a large amount of within-breed variation, which can be attributed to genetic and environmental causes as well as individual experiences (Mehrkam & Wynne, 2014). How these types of influence converge in the behavior of individual mixed breed dogs is not well understood.

Whilst over two million dogs entering United States shelters will find homes or return home to their owners, 20% will ultimately be euthanized (ASPCA, 2018). Without a national database that collects this information, these numbers will continue to be approximations and not take into account reasons for euthanasia (i.e., medical, behavioral, capacity, etc.). Thus far, however, researchers have identified dogs surrendered to the shelter by their owners to be at higher risk for euthanasia (Houpt, Honig, & Reisner, 1996; Zawistowski et al., 1998).

Bartlett, Bartlett, and Walshaw (2005) calculated that a 40% euthanasia rate at shelters in Michigan equated to roughly 2.5% of that state's annual dog population, and Patronek and Glickman (1994) arrived at similar percentages for Washington and Iowa. Whereas the national dog population model developed by Patronek and Glickman predicts a higher euthanasia rate than is approximated by more recent statistics, it is estimated that shelter euthanasia currently claims the lives of approximately 2% of the nation's dogs each year (ASPCA, 2018; APPA, 2016).

Having reviewed what is understood about the dogs that live in animal shelters, the aim of the following chapter is to uncover the breed identities of dogs living in animal shelters. Previous research in animal shelters has determined the breeds of dogs living in shelters by their visual appearance; however the genetic breed testing of such dogs is seldom conducted, and few studies have compared the breed labels assigned by shelter staff to the results of this testing.

SECTION 1

BREED IDENTITY OF DOGS LIVING IN ANIMAL SHELTERS

CHAPTER 2

A CANINE IDENTITY CRISIS: GENETIC BREED HERITAGE TESTING OF SHELTER DOGS

The American Pet Products Association (APPA) estimates from survey data that 78 million dogs live in American households (APPA, 2016). These were most commonly obtained from a family member or friend, an adoption organization, or a breeder (Campbell, 2012). The largest breed registry of purebred dogs in the United States, the American Kennel Club, presently recognizes 189 individual dog breeds (www.akc.org). In the late 1990s, purebred dogs were thought to have comprised approximately 50% of dogs in homes (New et al., 2000). Today, as the number of dogs registered to the AKC declines (Strander, 2014), it is possible that the percentage of purebred dogs in homes may also be waning, but no reliable data are available.

When Hoffman, Harrison, Wolff, and Westgarth (2014) asked animal shelter workers what criteria they used to determine breed assignment of dogs of unknown heritage, physical appearance was indicated as the primary means of identification, with characteristics such as the dog's size, weight, musculature, legs, tail and coat often mentioned. Considering the abundant diversity in modern dog breeds (Coile, 2007), morphological features may be one means to differentiate purebred dogs.

Notwithstanding its prevalence in animal sheltering, however, visual identification of breeds based on morphology has consistently failed to accurately describe the breed heritage of mixed breed dogs when compared to DNA analysis. Voith, et al. (2009) reported that shelter staff correctly assigned one breed within the dog's heritage in 7 out of 20 subjects; and in those cases, that breed often represented only one-eighth of the dogs' total breed make-up. When dog professionals were provided with videos for identification of these same 20 mixed breed dogs, on average fewer than 30% of participants were able to identify one breed in the dog's DNA analysis (Voith et al., 2013). Furthermore inter-rater reliability was low; and even when agreement about the predominant breed was greater than 50%, the breeds agreed upon for three of the seven dogs were not found in their genetic analyses.

These issues are particularly acute in the assessment of dogs belonging to the group commonly known as "pit bulls." Beginning in the 1980s, pit bulls have been characterized as a dangerous breed (Lockwood & Rindy, 1997), particularly from their history of association with dog-fighting and implication in dog-bite injuries and deaths (Sacks, Lockwood, Hornreicht, & Sattin, 1996; Sacks, Sattin, & Bonzo, 1989; Sacks, Sinclair, Gilchrist, Golab, & Lockwood, 2000). Consequently, breed-specific legislation was enacted across the United States to address this risk with local ordinances ranging from prohibiting ownership (Sec. 8-55, 1989 & 1996) to confinement restrictions and muzzling (Sec. 5-17, 1989 & 1999), to mandatory sterilization (Sec. 43, 2005). Thus far, limited empirical data has been published on the effect of these legislations on improved public safety; however breed bans in Spain (Rosado, García-Belenguer, León, & Palacio, 2009), the Netherlands (Cornelissen & Hopster, 2010), Canada (Clarke & Fraser, 2013), and Italy (Mariti, Ciceroni, & Sighieri, 2015) have failed to decrease bite incidents and a recent study from Ireland found no differences between restricted and non-restricted breeds in the severity of bites inflicted or the likelihood that the bite would need greater medical attention (Creedon, & Súilleabháin, 2017).

One complication in understanding the risk posed by pit bulls is identifying these dogs. The aforementioned US jurisdictions that ban these dogs use the preponderance of physical characteristics associated with the breeds of American Pit Bull Terrier, American Staffordshire Terrier or Staffordshire Bull Terrier as their means of positive identification. However breed characterization based on morphology has been found to be inconsistent among individual assessors and an unreliable means of identification compared to DNA analysis. Olson et al. (2015) reported that 50% of dogs assessed as a pit-bull-type breed at a Florida shelter lacked the signatures of the breeds associated with that label. Additionally, recent research has indicated that the label of "pit bull," independent of the dog's visible characteristics, can influence perceptions of a dog's attractiveness to potential adopters, as well as the dogs' length of stay in the shelter and adoption success (Gunter, Barber, and Wynne, 2016).

Advances in canine genomics allowed the advent of commercial genetic breed testing, making possible the identification of component breeds within mixed breed dogs. In 2005, researchers reported the first genomic draft sequencing of the domestic dog along with mapping of two-and-a-half million single nucleotide polymorphisms (SNPs) (Lindblad-Toh et al., 2005). Koskinen (2003); Irion, Schaffer, Famula, Eggleston, Hughes, & Pedersen (2003), and Parker et al. (2004) successfully assigned purebred dogs to their distinct breeds through the genotyping of varying numbers of allelic microsatellite markers. Boyko et al. (2010) used DNA samples from 915 dogs across 80 dog breeds (as well as a number of wild canids) to identify a relatively small number of genes of large effect that are responsible for physical traits such as body size, coat length, ear type, and snout length (see also Vaysse et al. (2011)). These developments are particularly noteworthy considering the relatively recent origins of dog breeds themselves, and allow for group classifications in the canine population based on genetic variation, and not solely their roles in society or their physical appearances (Parker & Ostrander, 2005).

The present study has two main aims. First, to report the breed heritage of a large sample of mixed breed shelter dogs based on genomic breed testing. We identify the breed signatures and the number of breeds detected in our sample, the amount a single breed typically contributed to a dog's breed heritage, the proportion of purebred dogs identified at the sheltering organizations and the impact of breed on length of stay. Second, to assess the success of visual breed identification by shelter staff at one of these locations by comparing the primary and secondary breeds indicated by staff and those identified by DNA analysis.

Methods

Subjects

From December 2014-August 2015, all dogs newly admitted to the Arizona Animal Welfare League & Society for the Prevention of Cruelty to Animals (AAWL: Phoenix, AZ, USA) were enrolled in the study; and from April 2015-April 2016, dogs admitted to the San Diego Humane Society and Society for the Prevention of Cruelty to

Animals (SDHS: San Diego, AZ, USA) were enrolled. AAWL and SDHS are limited-admission private animal shelters. At AAWL, nearly half of all dogs (47%) were transferred to the shelter from other welfare organizations. 38% of dogs were brought to AAWL by their owners (including returns) with only 15% arriving as strays. At SDHS, over forty percent of dogs (41.5) arrived as owner surrenders or returns with 31.4% as strays and only a small proportion (11.4%) transferred from nearby shelters. We collected records via software programs, PetPoint (Oakville, ON, CAN) at AAWL, and Shelter Buddy (Englewood, CO, USA) at SDHS, and we used the dogs' intake dates, outcome dates and types, and primary and secondary breeds in our analysis.

DNA Breed Testing

Buccal cells were collected from dogs' cheeks and gums via cytobrush kits provided by Wisdom Panel Canine DNA Tests (Mars Veterinary, Portland OR). These samples were allowed to dry and then placed into individual protective sleeves. Sleeves were collected into overnight courier envelopes in batches and shipped to GeneSeek Laboratory (Lincoln, NE) twice weekly for processing. Each kit number was activated online at the Mars Veterinary Wisdom Panel Business Portal (http://business.wisdompanel.com) prior to shipment. Once a kit was activated with the swab's sample ID and identifying information about the dog (i.e., name or shelter ID number), the laboratory then uploaded results to the Kit Status Checker area of the portal when analysis was completed.

With the Mars Wisdom Panel 2.0 DogTrax product, DNA is extracted from the buccal cells and typed at 321 single nucleotide polymorphisms (SNPs) across the canine genome using PCR amplification and base-specific cleavage. The Sequenom platform (Sequenom, San Diego, CA) was used for SNP genotype detection by matrix-assisted laser desorption/ionization time of flight mass spectrometry (MALDI TOF-MS) (Ehrich et al., 2005). Bayesian generative modeling utilizing a Mars Veterinary-proprietary Markov Chain Monte Carlo sampling process was used to translate genotype information to breed matches and develop a best-fit family tree model.

The Mars DNA database from which these breed signatures were identified was developed through the genotyping of over 13,000 purebred dogs. Mars Veterinary sampled 246 mixed breed dogs of known heritage to establish accuracy measurements for the Wisdom Panel 2.0 DogTrax product. The genetic breed test was found to have an overall positive predictive value greater than 90% at standard confidence levels for reporting of breeds within a dog's heritage. This accuracy was not dependent on number of breeds identified (Mars Veterinary, personal communication, January 4, 2018).

The Wisdom Panel DogTrax report includes breed signatures from three generations of ancestors from 209 breeds and varieties (Table 2-1) with the use of "mixed breed" for relatives in which no distinct purebred signature could be identified. Any ancestry contribution under approximately 12.5% is not reported. For this study, the two most predominant breeds were designated on the Wisdom Panel report analogous to the primary and secondary breeds reported on shelter kennel cards.

Shelter Breed Assignment

At SDHS, the dogs' primary and secondary breeds as determined by shelter staff were collected prior to receiving the results of the dogs' DNA tests. Breed assignment followed the shelter's current protocol based on visual identification. To assist in the visual breed identification of these dogs, shelter staff were provided with American Kennel Club Breed Identification Guides (American Kennel Club, 2014) and encouraged to use breed labels that were recognized breeds. A minimum of a primary breed was provided, but staff could also indicate a secondary breed or mix.

This study was exempted from review by the Arizona State University Institutional Review Board.

Statistical Analysis

Breeds reported from the Wisdom Panel DogTrax report were counted in two different ways. First, we calculated the total number of individually identifiable breeds and varieties found in the dogs analyzed in this study. Breed varieties include dogs of the same breed for which distinct subpopulations have been identified and assigned genetic signatures, such as by different countries of origin (e.g., the United States and United Kingdom), use (e.g., field and show), size (e.g., miniature and toy), and coat (e.g., longhaired and shorthaired). For the second analysis, varieties were reduced to their single breed population (such as Beagle or Dachshund). Where a single breed signature could not be conclusively identified at great-grandparent level, we applied the label "mixed."

Shelter breed identification data was standardized prior to analysis to remove data entry inconsistencies, spelling errors and to combine certain breed variations into single breed groupings (as above with dogs of the same breed that have different size and coat varieties). In addition, 10 dogs were excluded due to having been identified by a generic label (four “Shepherds”, two “Terriers”, and two “Spaniels”), or in cases where the Wisdom Panel DogTrax reports do not detect that breed (the only case was one Korean Mastiff), or where the breed is a recent hybrid (the only case was a “Labradoodle”). An additional 50 dogs were excluded because no visual identifications were recorded by staff. Length of stay (LOS) was defined as the number of days housed at the shelter from day of intake to day of outcome.

Results

Genetic Breed Markers

DNA analysis was performed and results returned for a total of 919 dogs, 459 at AAWL and 460 at SDHS. A total of 186 identifiable breeds and varieties were identified: 168 at AAWL and 166 at SDHS. Twenty of these signatures were exclusively found at AAWL, and 18 at SDHS. When signatures of different varieties of the same breed were combined into a single breed, 125 breeds were identified within the total sample, and 91 of those breeds (72.8%) were present at both AAWL and SDHS.

At the great-grandparent (GGP) level, 87.8% of the dogs had at least one relative who was identified as “mixed” (unidentifiable) breed. 4.9% of the 919 dogs (2.4% at AAWL, 7.4% at SDHS) were identified as being purebred dogs, with the most commonly identified being Labrador Retriever (5 individuals), American Staffordshire Terrier (5), and Yorkshire Terrier (5). In total, the 45 purebred dogs represented 22 breeds (Table 2-2). An additional 12 dogs (1.3%) were identified as having had two purebred parents of different breeds (Table 2-3). Only 11.6% could be correctly identified with one specific breed and no other purebred GGPs (the combination typically labeled a breed “mix”).

Thus, a total of 18.7% of dogs could correctly be identified by a single breed, two specific breeds, or one breed plus “mixed.” The remaining dogs had at least two identifiable breeds plus “mixed” in their three-generational breed heritage. While most dogs were of a multiple breed heritage, 44.5% of the dogs (AAWL: 42.7%, SDHS: 46.3%) were found to be at least 50% of one specific breed (Fig. 2-1).

The most common breeds identified at both shelters were similar. 24% of dogs at AAWL and 27.8% of dogs at SDHS had at least one American Staffordshire Terrier GGP. Broadening the analysis to include all the breeds typically classed as “pit-bull-type” (dogs with at least one GGP from American Staffordshire Terrier, American Bulldog, Bull Terrier, and Staffordshire Bull Terriers), these dogs accounted for 26.6% of intakes at AAWL and 30.7% of intakes at SDHS. The second most common breed signature at both shelters was Chihuahua, with 24% of AAWL dogs and 17.8% of SDHS having at least one GGP of Chihuahua heritage. Poodle was the third most common breed signature, appearing in 15.3% of the AAWL dogs and 14.6% of SDHS dogs. Although the order of prevalence varied, Boxer, German Shepherd Dog, Labrador Retriever, Cocker Spaniel and Dachshund were in the 10 most commonly identified breeds for both shelters, although in most cases the average concentrations for these breeds dropped closer to two GGP (Tables 2-4 and 2-5).

Although pit-bull-type dogs were the most common breed signatures identified at the GGP level at both shelters, the average concentration of pit-bull-type ancestry (the percentage of that breed in an individual dog’s heritage) was low to moderate. On average, dogs at AAWL identified as having a pit-bull-type breed in their heritage had a concentration of 38.5% (approximately three GGP out of eight), and SDHS dogs had a concentration of 48.4% (nearly 4 GGP out of eight).

As observed with pit-bull-type dogs, the average concentration of Chihuahua GGP in dogs with any Chihuahua breed signatures was relatively low. Out of a combined total at both shelters of 193 dog with Chihuahua signatures, only three were purebred. Both shelters saw average Chihuahua breed concentrations of 38-39%, indicating just over three GGP out of eight in an individual dog's heritage.

Length of Stay

The length of stay (LOS) at the two shelters was comparable, with dogs at AAWL kenneled an average of 23.6 days awaiting adoption while SDHS dogs' average LOS was 25.8 days. There was a noticeable difference, however, between dogs with signatures of pit-bull-type breeds when compared to dogs without. The difference was similar at both shelters, but more pronounced at SDHS.

Dogs with pit-bull-type ancestry at both shelters had a mean length of stay nearly twice as long as non-pit-bull-type breeds. On average, dogs with no DNA contribution from pit-bull-type breeds stayed in the shelter for 19.7 days as compared to 37.5 days for dogs with at least one pit-bull-type GGP (Table 2-6). When disaggregated by shelter, however, there was a difference in magnitude. At SDHS, a significant independent samples t-test was found for the 23.2-day difference in overall length of stay between pit-bull-type breeds and other dogs. In contrast, that difference was only 12.0 days at AAWL, which, while still statistically significant, is half the difference found at SDHS. It should be noted that in both cases Levene's Test for Equality of Variances failed, resulting in substantial reductions in the degrees of freedom to adjust for the variance differences. Table 2-7 provides details of these test statistics.

Percentage of pit-bull-type heritage correlated positively with length of stay at SDHS (r (127) = .373, p < .001), but not at AAWL (r (117) = .039, p =.673). The percentage of mixed heritage (where a specific breed could not be identified at the great-grandparent level) was not significantly correlated with length of stay at AAWL. However, at SDHS length of stay was significantly negatively correlated with the percentage of mixed breed identified (r (360) = -.152, p = .004).

While the total number of identifiable breed signatures contributing to a dog was not significantly correlated with its length of stay at either shelter, there was a small but significant positive relationship at SDHS between length of stay and a dog having at least 50% of its DNA from a single breed signature (r (425) = .112, p = .02). Further investigation of this result found that the significant correlation was only for dogs of pit-bull-type breed heritage, (r (127) = .220, p = .013).

Staff Identification of Breed

Visual identification of the dog's primary breed by shelter staff matched the most prevalent breed identified by the Mars Wisdom Panel DogTrax analysis in 56.7% of the 384 dogs tested. Prevalence was defined as the greatest number of same breed signatures identified with two or more great-grandparents. Broadening the criteria for correct identification to ignore the order in which breeds were labeled by shelter staff (i.e., primary and secondary), we found that 67.7% of these dogs had at least one breed correctly identified, while 33.3% of visual breed assignments by staff failed to correctly identify any of the up to eight breeds indicated by DNA analysis. Only 10.4% of dogs (40 out of 384) were correctly identified by staff in both the primary and secondary breed assignments (which we describe as a “complete match”); and in all but four of those cases, the breeds were in the correct order. However, more than half of the cases of successful complete matches by shelter staff (55.6%) concerned purebred dogs.

Of the 400 dogs at SDHS for whom both breed assignment and DNA testing results were obtained, 124 were identified as having a breed heritage consisting of at least one pit-bull-type relative. Considering those dogs in whom the pit-bull-type concentration was 25% or higher (114 dogs), shelter staff correctly identified these dogs’ primary breed assignment as a pit-bull-type in 67.0% of cases. An additional 8.8% of dogs were correctly identified when including assignments that were placed in the secondary position.

Twenty-seven dogs of pit-bull-type heritage were not correctly identified by shelter staff as being pit bull-type dogs. Of those 27 dogs, 20 (74.1%) were only one-quarter pit-bull-type. Most commonly the incorrectly identified dogs were listed as Labrador Retriever mixes by the staff. Conversely, four of the 270 dogs that did not have any pit-bull-type breeds in their DNA analysis were identified as pit-bull-type dogs by shelter personnel (Table 2-8). The DNA for these dogs showed them to be either Boxer or Rottweiler mixes.

In exploring the relationship between identification and pit-bull-type heritage, we found a significant correlation between the number of DNA-identified pit-bull-type relatives and the probability that shelter staff identified the dogs correctly (r (85) = .75, p

< .001). Dogs whose heritage was 25% pit-bull-type or less were the most likely to be misidentified by staff as not having any of these breed ancestors. Conversely, shelter personnel were 92% successful in identifying dogs with 75% pit-bull-type heritage or higher (Fig 2-2).

Discussion

By testing over nine hundred dogs at two animal shelters in the United States, we were able to satisfy our aim of better understanding the breed identities of shelter dogs via commercially available genetic testing. To our knowledge, this is the largest reporting of breed heritage in sheltering to-date.

While organizations such as the Humane Society of the United States have reported that 25% of shelter dogs are purebreds (Humane Society of the United States, n.d.) the results of our study do not confirm this number. Instead, we found approximately 5% of shelter dogs consisted of only one breed with the majority of these purebreds identified in San Diego.

The overall occurrence of purebreds in our sample is much lower than proportions of purebred dogs surrendered to shelters by their owners reported in Salman et al. (1998) and Patronek et al. (1995) (30 and 40 percent, respectively). There are several possible reasons for this discrepancy between our study and these earlier reports.

First, neither of the earlier reports used genetic breed testing: thus their estimates, based solely on owner report and visual identification, may be unreliable. Second, the reduced presence of stray dogs in our sample as compared to the national average (ASPCA, 2018) may have diluted the overall prevalence of purebreds. Third, another possibility for this discrepancy is that previous findings are roughly twenty years old, and shelter demographics have changed.

Kass, Johnson, and Weng (2013) reported two California counties saw a reduction of over 35% in the number of dogs arriving at shelters from 1993 to 2006, and Morris and Giles (2014) reported a reduction of nearly 45% in the number of dogs taken into Denver area shelters between 1998 and 2010. The latter study attributes years of low-cost spay and neuter policies as a possible cause of these declines. If the number of purebreds arriving at shelters has, in fact, declined or is rarer than once believed, and the prevalence of dogs with a multiple breed heritage is more common, it is possible then that the source of pet overpopulation in these communities is not the irresponsible breeding of purebred dogs but mixed breed dogs having unwanted litters. Additionally, we find that the most popular breeds registered with the American Kennel Club in these cities during this time include Bulldogs, French Bulldogs, and Labrador Retrievers in San Diego and Labrador and Golden Retrievers and German Shepherds in Phoenix (American Kennel Club, personal communication, December 29, 2017). While some of these breeds were prevalent as purebreds and contributed to the mixed breed heritage of dogs in our sample; others were not, suggesting that owners that are acquiring, registering, and owning purebred dogs may not be as large as an influence on the shelter population as once believed.

When considering pedigree status as a factor in adoption success, Diesel, Smith, and Pfeiffer (2007) found purebreds had shorter shelter lengths of stay than mixed breed dogs; and Siettou, Fraser, and Fraser (2014) and Lepper et al. (2002) concluded that purebreds had a 1.67 and 1.43, respectively, times greater likelihood of adoption compared to mixed breed dogs. While it is recognized that dog breeds are perceived differently (Gunter et al., 2016; Walsh, McBride, Bishop, & Muser Leyvraz, 2007), it is unclear whether potential adopters in shelters are recognizing purebreds by their appearance and choosing based on beliefs about breed, or are influenced by how the shelter has conveyed their pedigree status. Given the low prevalence of purebreds found in our sample compared to the percentage that is often cited, shelter indications of breed status may be a more influential aspect in adopter decision-making than previously considered.

Although purebreds were very infrequent in our sample, American Staffordshire Terriers, Labrador Retrievers, and Yorkshire Terriers were the most commonly observed breeds (with five each). Without enforced registration, it is difficult to know the prevalence of different dog breeds in the United States, but these breeds are among the most commonly treated breeds at a major chain of pet hospitals in the United States (Banfield, 2016) Labrador Retrievers also have the highest number of registrations with the American Kennel Club (American Kennel Club, 2016). When we consider the most often identified breed signatures within the mixed breed dogs were American Staffordshire Terrier (or more broadly a pit-bull-type breed) and Chihuahua (the number one Banfield-treated breed), it seems possible that the prevalence of these dogs in shelters, whether as purebreds or as mixes, is more likely related to their popularity amongst owners than abandonment due to breed-specific problems (Lepper et al., 2002).

Most animal shelters describe dogs as either purebreds, single breed with mixed or with primary and secondary breeds listed. Previously, breed label has been shown to affect dogs' length of stay (Brown, Davidson, & Zuefle, 2013), as well as which dogs are selected for transfer programs (Simmons & Hoffman, 2016), and may even play a role in how lost dogs are reclaimed by their owners (Weiss, Slater, & Lord, 2012). However, our results here suggest that the method of description used in shelters does not accurately represent the breed heritage of three-quarters of dogs sampled. Instead most dogs were comprised on average, of three breeds, with some dogs having up to five different breed signatures identified at the great-grandparent level. While the removal of breed labels has been suggested to improve adoptions and length of stay (Gunter et al., 2016), it may also be a low-cost strategy that acknowledges the inherent breed complexity of homeless dogs in animal shelters.

At both shelters studied here, pit-bull-type dogs waited longer to be adopted. Previous studies have also found these dogs have longer lengths of stay (Gunter et al., 2016; Protopopova et al., 2012). Particularly at the San Diego shelter, we found a relationship between the number of pit-bull-type relatives that were indicated in the dogs' breed heritage and increased time spent in the shelter awaiting adoption. More pit-bull-type relatives in a dog's heritage also meant staff were more likely to correctly identify the dogs. Together, this may suggest that as a dog's heritage becomes more predominantly pit bull, adopters and shelter staff can perceive this in the dog's appearance and act accordingly.

If animal shelters want to characterize the breed heritage of today's shelter dogs, genetic testing is a more accurate and comprehensive method of description than visual identification. In our sample, we found no evidence of a relationship between the number of breeds identified in a dog's DNA analysis and their length of stay at the shelter, suggesting that a dog's attractiveness as perceived by potential adopters is not governed by purebred status alone. Instead, it is likely that shelter dog attractiveness as perceived by shelter visitors is more strongly affected by certain aspects of the dog's appearance, such as coat color, length, and overall size (Protopopova & Gunter, 2017).

Using DNA-derived breed heritage could also help shelters better infer the influence of breed upon outcomes like adoption, length of stay, and even adopter satisfaction. Beyond well-established breed-specific traits such as retrieving and pointing (Coppinger & Coppinger, 2001), it is conceivable that behavioral differences between dog breeds do exist and expectations about breed-specific behavior are warranted. In Duffy, Hsu, and Serpell (2008), answers by owners on the Canine Behavioral Assessment and Research Questionnaire (C-BARQ) yielded distinct differences in aggression by their dogs towards themselves, strangers, and other dogs. Yet while these significant differences have been observed in survey-based studies of behavior, experimental studies investigating cognitive and temperamental differences between dog breeds have not found robust results. To our knowledge, no study to-date has demonstrated evidence of behavioral differences due to specific breed influences in dogs of mixed breed heritage. We suggest that if shelters are to reliably inform potential adopters about expectations of dogs based on breed, a better understanding of how multiple breeds interact in the behavior of the mixed breed dog is needed.

Shelter staff at SDHS were correct in their visual identification of at least one breed in a dog's heritage over two-thirds of the time. This contrasts with prior research in which shelter staff and dog care professionals were found to be correct with only 30-35% of dogs tested (Voith et al., 2009; Voith et al., 2013). We also found incidences of over- and under-identification of pit-bull-type dogs to be much lower than previously reported (Olson et al., 2015). It is possible that the size of the sample, method of sampling, population of dogs sampled, and skill of the staff contributed to such differences. Our findings do suggest, however, that visual breed identification is much more difficult when assigning both a primary and secondary breed to mixed breed dogs, with only 5% correctly assigned. When considering the breed complexity indicated with these dogs, breed assignment by visual identification appears to be a much more complicated endeavor than previously imagined and a likely untenable process for shelters to carry out successfully.

Nevertheless, identifying a dog's breed heritage alone cannot predict how those multiple breeds will then interact to influence the behavior of the individual dog. The degree to which an eighth, a quarter or even one-half of a particular breed consistently affects behavior is unknown. Regardless of a dog's breed heritage, morphology remains an influential factor in adopters' decision-making (Weiss, Miller, Mohan-Gibbons, & Vela, 2012; Protopopova et al., 2014). Tracking the physical characteristics, rather than visually-identified breed, of shelter dogs, and the outcomes of these animals, would help us understand the relationship of morphology to adoption success and length of stay (Protopopova & Gunter, 2017). It may also prove useful in clarifying preferred morphology from perceived breed and help transfer programs meet the supply needs of shelters across the United States (Simmons & Hoffman, 2016).

In describing the number of purebred dogs in our study, our sampling method may have been unintentionally biased by the use of two limited admission facilities instead of municipal shelters that may have more purebred dogs in their care. However, a recent web-based survey of shelter dog adoption profiles across the United States arrived at similar proportions of purebred dogs at 18 shelters (National Animal Interest Alliance, 2015). As our study only included one shelter each in Arizona and California, it is inevitable that other areas of the country may identify other breeds not found in our sample with differing prevalence rates. While we used the most established, commercially available genetic breed testing service in our study to identify the breed heritage of these shelter dogs, dogs found to be mixed or unknown at the third generational level may be identifiable as additional breeds are sequenced and added to the Mars DNA database.

Conclusion

We found that over 100 breed signatures were identified at each shelter in our genetic breed testing with over 91 breeds shared between sites. Breed ancestries ranged from having one to five unique breed signatures identified (7%). On average, purebreds represented less than 5% of dogs tested with individuals most often having three breed signatures identified within their genetic heritage. In order of prevalence at AAWL and

SDHS, American Staffordshire Terrier, Chihuahua, and Poodle were the most common breeds identified. Concurrent with previous studies, dogs with pit-bull-type ancestries were found to have longer lengths of stay than other dogs. While the shelter staff at SDHS was able to successfully identify based on appearance at least one breed in the dog's genetic heritage nearly two-thirds of the time, their ability to correctly identify more than one breed fell to roughly 10% with over half of those properly-identified dogs being purebreds. We did find, though, that as the number of pit-bull-type relatives increased in a dog's heritage, so did the staff's ability to correctly identify its breed type. Overall when we consider the complexity in breed heritage of these shelter dogs coupled with the failure to correctly identify multiple breeds based on morphology and the lack of any scientific basis to judging how these breed signatures interact within the individual dog, we believe shelters should instead focus their resources on communicating the morphology and behavior of the dogs in their care to best support matchmaking and adoption efforts.

SECTION 2

RELINQUISHMENT OF DOGS TO ANIMAL SHELTERS

CHAPTER 3

REVIEW OF CANINE RELINQUISHMENT IN ANIMAL SHELTERS

In this chapter, I will review what we understand about dogs that are surrendered by their owners to animal shelters in the United States and around the world. By identifying characteristics of these dogs, their owners, and reasons why these relationships failed, we can develop evidence-based interventions to decrease the likelihood of such an outcome occurring for owners in the future.

Our understanding of relinquished dogs and their owners has been heavily influenced by research conducted on behalf of the National Council on Pet Population Study and Policy in the mid-nineties (Salman, New, Scarlett, Kass, & Ruch-Gallie, & Hetts, 1998; Salman et al., 2000; New et al., 1999; New et al., 2000; Scarlett, Salman, New, & Kass, 1999; Kass, New, Scarlett, & Salman, 2001). Studies by Patronek, Glickman, Beck, McCabe, & Ecker (1996) and Patronek et al. (1997) conducted in the St. Joseph County area of Indiana also identified relinquishment risk factors by focusing on differences in the behavior of surrendering and non-surrendering owners.

Comparing the characteristics of dogs relinquished to shelters with those of owned dogs in homes, these shelter dogs were often under the age of two; in fact, as dogs increased in age, their chances of relinquishment were reduced. The same relationship was seen with length of ownership (New et al., 2000). Diesel, Brodbelt, and Pfeiffer (2010) found that 65% of dogs surrendered to Dogs Trust animal shelters in the United

Kingdom were three years old and younger with nearly a similar percentage owned for less than a year. New et al. (2000), purebreds in the United States were more often in owned homes, and relinquished dogs, in general, were most commonly obtained from friends and animal shelters. House soiling, destruction, hyperactivity, and fear issues were more prevalent in relinquished dogs than dogs not relinquished. This suggests that follow-up support for owners when the human-animal bond is newly formed and likely at its most vulnerable, particularly with adolescent dogs, may reduce the probability of relinquishment.

New et al. (2000) found that owners of relinquished pets in regions across the United States tended to be under 50 years of age with a trend of decreasing incidence of surrender with increasing age. Not seeking out veterinary services, unmet expectations, and lack of participation in obedience classes were the owner behaviors most strongly associated with surrender (Patronek et al., 1996). Salman et al. (1998) reported that relinquished dogs more often had been trained by the owner only, had not attended obedience classes or received other forms of professional training advice. Owners of these surrendered dogs were most often Caucasian and had earned a high school diploma or beyond. No observed income-to-relinquishment relationship was observed. Without comparison groups of owned dogs in this study, it is difficult to determine whether these are indeed risk factors or simply characteristics of the dog-owning population in general. In a study that surveyed owners relinquishing their pets to animal shelters, Salman et al. (1998) found that housing challenges, non-aggressive problem behavior, and lifestyle complications represented the largest proportion of reasons given. Similarly Weiss et al.

(2014) found that personal, moving, and landlord issues were much more frequently cited by owners in two cities in the eastern United States as reasons for surrender than behavior and health concerns. Moving was most often provided as the reason for relinquishment, with housing restrictions commonly indicated as additional grounds (New et al., 1999).

Shore, Petersen, and Douglas (2003) reported that 85% of relinquishing pet owners designated moving as their primary motivation for surrender, with 70% indicating that there was no secondary reason (such as behavior) behind the decision. When Marston et al. (2004) asked Australian owners for their relinquishment reasons, factors pertaining to the owner and not the dog comprised the majority of reasons, with housing issues again topping the list. In Belgrade, Serbia, owners surrendering their dogs most often gave reasons related to finances (Vučinić, Đorđević, Teodorović, Janković, Radenković-Damnjanović, Radisavljević, 2009). Diesel et al. (2010) found that while problematic behavior and other behavior-related reasons were indicated in at least 35% of owner surrenders in the United Kingdom, the majority of reported reasons were housing, personal issues, and situations unrelated to the dog. Kim, Kim, Lee, Choi, Kim, & Shin (2010) failed to find a relationship between presence of behavioral problems and owner relinquishment in Korea. While a quarter of United States canine relinquishments reported were requests for euthanasia (Kass et al., 2001), owners making this request did so overwhelming for reasons of old age and illness, as did owners reported in Vučinić et al. (2009).

In cases where problematic behaviors were indicated by dog owners in the United Kingdom as grounds for relinquishment, problem behaviors unrelated to aggression, particularly destruction, were more frequently reported in aggregate than aggressive behavior toward people and other pets (Diesel et al., 2010). Salman et al. (1998) found that, as a reason for relinquishment by United States owners, aggression towards people and other animals, even when combined, did not equal the total of all other behavioral problems combined – which most often included escaping, house soiling, destruction, and disobedience. When examining behavioral reasons given for relinquishment individually, however, biting and human aggression easily topped the reasons for relinquishment (Salman et al., 2000). Nonetheless, this suggests that while aggressive behavior is certainly a cause for relinquishment in the United States and United Kingdom, other behavioral concerns – that could be potentially easier to address – were reported more often.

Once adopted, dogs face the risk of being returned to the animal shelter. Return rates of adopted dogs across the United States, United Kingdom, and Italy range from 14.6-15.2% (Posage, Bartlett, & Thomas, 1998; Marston et al., 2004; Mondelli, Prato Previde, Verga, Levi, Magistrelli, & Valsecchi, 2004; Diesel, Pfeiffer, & Brodbelt, 2008), while Australia's adopters return their dogs about half as often (Marston et al., 2004). Approximately 35 to 50% of these dogs are returned within 2 weeks to 1 month after adoption (Shore 2005; Diesel et al., 2008; Gunter, Protopopova, Hooker, Der Ananian, & Wynne, 2017). In fact, half of the owners reported observing the problematic behavior, which ultimately led to the return, within 24 hours of adoption (Shore, 2005).

Wells and Hepper (2000) found that 90% of surrendering owners at a shelter in Northern Ireland reported a behavioral problem within the first month of adoption (compared to 67% of owners who kept their dogs). Similar to New et al. (2000), the most common behavioral issues were fearfulness and hyperactivity. Interestingly, Mondelli et al. (2004) found that only 20% of new owners in Italy whose dogs were previously adopted and then returned to the shelter reported the same behavioral problem as the original owner. Duffy, Kruger, and Serpell (2014) described only three behavioral problems reported by relinquishing owners were positively correlated with observations of the same behavior in the new home: aggression toward strangers, inappropriate chewing, and home-alone urination. In a study carried out in the United Kingdom by Stephen and Ledger (2007), less than half of the problem behaviors indicated by relinquishing owners were observed by the new adopter (with one-third of those being related to the veterinarian). There are several reasons why this might be the case. First, these differences may be related to the lack of candor from surrendering owners when reporting certain types of aggression and fear (Segurson, Serpell, & Hart, 2005). Second, it could be that perceptions of behavioral problems may differ between owners. Finally, it is possible that some behaviors may simply be dependent on the environment in which the animal is living.

The reasons why dogs are returned to animal shelters are similar to why dogs are surrendered. In both the United States and Italy, the vast majority of returned dogs are under two years of age (Mondelli et al., 2004; Shore 2005). Owners most frequently cite housing and personal issues as reasons for re-relinquishment, followed by behavioral problems unrelated to aggression and then failure to cohabitate successfully with other pets and people, which can include aggression (Mondelli et al., 2004). Shore (2005) reported that problem behaviors – not including aggression – were most frequently offered by surrendering owners in the United States, but issues with other pets, children and human aggression (albeit in only three cases) were, in total, given nearly as often, followed closely by housing and lifestyle reasons. Over half of surrendering adopters were uncertain or did not plan to adopt another dog in the future (Shore, 2005), suggesting how influential adoption failure may be in future obtainment decisions.

Nearly three-quarters of the research on relinquishment, primarily conducted in the United States and Europe, has examined the reasons why owners surrender their pets. Conversely, only 15% has directly investigated interventions designed to abate owner relinquishment (Coe et al., 2014). With this paucity of attention prevention has received, the following chapter examines the efficacy of a post-adoption intervention intended to reduce returns by encouraging physical activity between adopters and their dogs.

SECTION 2

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CHAPTER 4

IMPACTS OF ENCOURAGING OWNERS TO WALK THEIR DOGS ON THE RETURN OF NEWLY ADOPTED DOGS TO AN ANIMAL SHELTER

The American Society for the Prevention of Cruelty to Animals (ASPCA) estimates nearly over 3 million dogs enter shelters each year. While a-million-and-a-half will find new homes, one-fifth of dogs living in animal shelters will ultimately be euthanized (ASPCA, 2016), with owner-surrendered dogs at the greatest risk of this outcome (Houpt et al., 1996; Zawistowski et al., 1998).

Prior research suggests that approximately 15% of dog adoptions across the United States, United Kingdom, and Italy fail (Posage et al., 1998; Marston et al., 2004; Mondelli et al., 2004; Diesel et al., 2008), while Australians return dogs on average about half as often (Marston et al., 2004). When we consider the emotional impact of failed companionship on the person (Shore, 2005), it’s likely that returned adoptions affect future ownership of shelter pets.

Several studies have investigated the variables that contribute to failed adoptions. While New et al. (2000) indicated a relationship between canine problem behaviors and relinquishment, other studies have found that housing and personal issues were often provided as reasons for relinquishment, followed by various behavioral issues unrelated to aggression, and finally, incompatibility with other pets and people, including aggression (Mondelli et al., 2004; Shore, 2005). Half of the owners surveyed by Shore

(2005) reported seeing a problem within 24 hours of adoption, with an additional 17% identifying a problem within the first week. Actual returns at the shelter mirrored these reports: 34% of failed adoptions occurred within seven days and another 20% in the second week (Shore, 2005).

Training and behavioral support post-adoption may play a pivotal role in keeping adopted dogs in their new homes. Clark and Boyer (1993) reported that owners who attended training and behavior counseling reported fewer problem behaviors, improved obedience, and a stronger bond with their dogs. Participation in dog training has been shown to reduce the likelihood of certain behavioral issues (Jagoe & Serpell, 1996), and improve the dog's obedience (Kobelt, Hemsworth, Barnett, & Coleman, 2003; Kutsumi, Nagasawa, Ohta, & Ohtani, 2013). The type of dog training was also found to be related to canine behavioral issues, with the use of positive punishment associated with higher problematic behavior (Blackwell, Twells, Seawright, & Casey, 2007). However, other studies have found no clear effect of dog training on reported behavioral problems (Pirrone, Pierantoni, Mazzola, Vigo, & Albertini, 2015), suggesting the need for further research.

Owners who receive helpful behavioral advice may be at a reduced risk for relinquishing their dogs (Patronek et al., 1996) and more likely to seek out such support when it is free (Shore, Burdsal, & Douglas, 2008). In fact, Diesel et al. (2008) found that adopted dogs showing aggression towards people had more than 11 times higher odds of being returned. Yet, when the owners of aggressive dogs contacted the animal shelter seeking advice in this study, the odds of relinquishment were cut in half.

Considering the relationship between how attached an owner is to their dog and their satisfaction with their dogs' behavior (Serpell, 1996), it is possible that reduced attachment may be related to relinquishment (Marston, Bennett, & Coleman, 2005; Kwan & Bain, 2013). Meyer and Forkman (2014) found that owners who did not participate in hobbies with their dogs showed less emotional closeness to them than owners who involved themselves more with their dogs. Higher levels of dog owner satisfaction have also been related to owners having a preference for and a motivation to exercise (Curb, Abramson, Grice, & Kennison, 2013). When owners spend more time engaged in activities with their dogs, they report decreased barking and aggressive behavior and more engagement in training (Bennett & Rohlf, 2007). Kobelt et al. (2003) found that frequency of walking was negatively correlated with problem behaviors such as hyperactivity and barking.

Thus, previous research has suggested that owners who surrender their dogs, more often report unacceptable behavior with their dogs within the first month of adoption than those who keep their dogs (Wells & Hepper, 2000). However, it may be possible to influence the dog's behavior or the adopter's perception of it by providing behavioral support and asking the adopter to engage in certain activities with their new dogs. To date, post-adoption interventions designed to reduce the rate of return of adopted shelter animals have received relatively little attention from researchers (see Coe et al., 2014, for a review of available studies). In the present study, we hypothesized that new adopter-dog pairs assigned to a post-adoption intervention promoting activity with the owner, and providing training advice and in-person behavioral support, would be more active and have lower return rates compared to pairs in the control condition that only received information already included in shelter's adoption materials.

Methods

Participants

From May 2014-May 2015, new adopters of dogs from the Arizona Animal Welfare League & Society for the Prevention of Cruelty to Animals (AAWL: Phoenix, AZ, USA) were contacted via email the day following adoption, inquiring about their interest in participating in a study about dog walking and dog-owner behavior. All dogs adopted from the shelter's two locations, AAWL and Chandler Fashion Center off-site adoption location (Chandler, AZ), were eligible for participation in the four-week study. If contact was not made the day after adoption, adopters were also contacted two days and four days afterward via telephone. Adopters had the opportunity to not respond or opt out, in which case no further contact was attempted. Adopters were asked to complete an informed consent form upon study enrollment. Adopters in both groups could discontinue their participation at any time during the study by contacting the researchers or no longer completing the weekly surveys. All procedures were approved by the Arizona State University Institutional Review Board.

Experimental Design

Upon enrollment in the study, adopters were placed randomly in one of two conditions: the activity intervention group or the control group. All adopters were asked to complete an initial survey to obtain their baseline physical activity levels prior to adopting the dog. In addition, we asked whether the adopter was a first-time dog owner, if there were resident dogs in the house prior to adoption, as well as the adopter's age, sex, race, highest education level completed, and annual income range.

Adopters in the intervention group received five weekly emails (baseline and Weeks 1-4) containing health advice which described the benefits of physical exercise, how to incorporate physical activity into their daily routine, guidelines regarding the amount and speed of walking, and encouraged adopters to take part in these activities with their dog and other adopters. The behavior advice described proper equipment for walking their new dog, how to use food in training, reducing their dog's energy before walking, training techniques to reduce pulling on-leash, and how to successfully encounter dogs and people while on-leash (Appendix A). In addition, they received a weekly invitation to join a group walk with the dog.

Owners in the control condition received five weekly emails (baseline and Weeks 1-4) which contained information given to all dog adopters about feeding, resident dog introductions, exercise, crating, and introducing the dog to children (Appendix B).

Both groups received weekly emails with hyperlinks to a Qualtrics (Qualtrics, Provo, UT, USA) survey. This survey contained questions about the number of days each week they walked with their dogs for at least 10 min, the average duration of those walks, whether they still owned their newly adopted dog, and whether they were experiencing any problem behaviors (Appendix C).

During Weeks 1 and 4, two additional series of questions were asked regarding owners' sense of obligation to their dogs, dog walking self-efficacy, and perceptions of their dog's behavior while on-leash. These questions have been previously used to assess factors related to owners walking with their dogs (Hoerster et al., 2011). In the present study, a 7-point Likert scale ranging from Strongly Agree (1) to Strongly Disagree (7) was used. Answers given by owners regarding their dogs' behavior on-leash were reverse-scored for ease of interpretation in the data analysis.

Group walks

Weekly group walks for the adopters in the experimental condition were led by a dog trainer at one of four locations in the Phoenix area. These locations were selected based on zip code density mapping of previous dog adopters from AAWL and were systematically rotated throughout the study. Over the course of the four-week intervention, adopters were invited to attend one walk at each location.

During the walk, trainers reiterated the activity and behavioral advice received in that week's email, answered any behavioral questions asked by adopters and led the group on a 30-40 min trail or path walk. Attendance was assessed each week, and owners who attended received a Whistle® accelerometer (Whistle Labs, Inc., San Francisco, CA, USA) that recorded the duration of their dogs' daily activity during the study.

Measures of return rates

Returns of dogs to AAWL by adopters participating in both the activity and control conditions were reviewed throughout the study and for eight months after the study ended using the shelter's database records (PetPoint, Rolling Meadows, IL, USA).

Statistical Analysis

To reduce the number of questionnaire variables, a principal components analysis (PCA) was applied to explore the factorial structure of the obligation, self-efficacy, and behavioral perception question raw scores obtained at Weeks 1 and 4. Slightly more than 50% of participants completed both Week 1 and Week 4 questions, so we were unable to calculate a reliable measure of change from Week 1 to Week 4. As such, we used loadings from whichever individual week was answered or an average of the two when both weeks were provided. A final PCA was then conducted to identify the factorial structure of the obligation, self-efficacy, and behavioral perception scores. As in the initial PCA, two component loadings were identified that explained 62.9% of the variance in the questionnaire answers. Unless answers had missing raw scores, each participant received Component 1 and Component 2 loading values.

The number of days walked each week and duration of those walks were combined to yield a total number of minutes reportedly walked each week by owners with their dogs. Due to low turnout in the weekly group dog walks (12.6%) in which the Whistle® accelerometers were provided to adopters, data collected from these devices was not analyzed. To test whether the control and treatment groups differed in minutes of walking at baseline, duration of walking reported prior to acquiring dogs was compared using an independent samples t-test. To test whether weekly physical activity changed over the course of the study, we analyzed differences in weekly physical activity at Weeks 1 and 4 with a mixed linear model with subject as the random effect and weekly time-point as the fixed effect. Owners' weekly walking-based physical activity with their dogs did not significantly change between weeks, so an average of walking activity was calculated for each participant. Average walking activity was based on the weekly values the owner reported walking his/her dog over Weeks 1 and 4.

A multiple linear regression analysis with backward elimination was employed to determine whether average walking activity could be predicted from experimental condition, demographics of the dog or adopter, dog walk attendance, either component loading, or return of the dog. A logistic regression analysis with backward elimination was used to determine whether the return of adopted dogs could be predicted from either experimental condition, dog or adopter demographics, walking activity, dog walk attendance, or the component loadings. In both analyses, dummy variables for race and education were created for each group other than White/Caucasian and bachelor's degree, respectively, as these were the largest groups within the two predictors.

Results

Post-adoption, 928 new owners were contacted to participate in the study of whom 236 (25.4%) agreed to enroll. Of those adopters, 199 returned at least one survey (either baseline, Weeks 1-4) containing data we were able to use in our analysis; 93 in the control group (46.7%) and 106 (53.3%) in the intervention.

Of 171 baseline surveys completed by participants in the study, the mean age of adopters was 41.19 years (*SD* 15.24). Most adopters identified as White/Caucasian (81.7%) with the most common education level obtained being a bachelor's degree (39.6%). The average income range was $50,000-59,000. Most adopters (88.8%) were not first-time dog owners; however, they most often did not have a resident dog in the house at the time of adoption (42.4%). If there was a resident dog(s), one dog (32.9%) was most often reported. The mean age of dogs at the time of adoption was 637.71 days

(*SD* 686.76) with a median of 374 days. The mean weight of adopted dogs was 9.75 kg (*SD* 7.78) with a median of 6.58 kg.

To uncover any systematic patterns in owner responding, an initial PCA using Varimax rotation with Kaiser normalization was performed on the nine obligation, self-efficacy, and behavior answers provided by 174 adopters. Two components with eigenvalues greater than one were obtained. Examining the completion of survey questions by participants across the study, only 53.4% of the adopters provided answers to the obligation, self-efficacy, and behavior questions at both Weeks 1 and 4. As such, raw scores for the week that was answered were used or an average when appropriate.

A final PCA using Varimax rotation with Kaiser normalization was then performed with these averaged raw scores. We found two components with eigenvalues greater than one and with minimal correlation between them. The rotated component matrix for this final solution is presented in Table 4-1. These two orthogonal components explained 62.9% of the variance in the adopter answers. Component 1 contained the obligation and self-efficacy questions. These five questions describe the owner's commitment and beliefs about their walking habits. Component 2 contained questions about the adopter's perceptions about their dog. These four questions, unlike Component 1, were about behavioral barriers (hyperactivity, pulling) that the owner would experience when walking the dog on-leash.

To compare the control and treatment groups for differences prior to intervention, an independent samples *t* test was performed on the 162 baselines measures of weekly activity. Levene's test indicated that the homogeneity of variance assumption was likely violated (*p* = .055). As a conservative measure, we used a Welch's *t* test for the analysis. The *t* test indicated no statistically significant difference between the group means at baseline, *t* (151.79) = .19, *p* = .67 (two-tailed). The means for the control and intervention conditions were 358.04 min (*SD* 386.83) and 334.11 min (*SD* 313.13), respectively. In all subsequent analyses, minutes of weekly walking-based activity from Weeks 1-4 or their averages were used.

Over the course of the study, we collected a total of 472 weekly self-reports by adopters describing the amount of activity with their dogs (wherein minutes and days were both reported). The mean was 237.57 min (*SD* 220.95) with a range of 5-1260 reported; the median was 175. We subsequently analyzed weekly activity in minutes from Weeks 1-4 using a repeated mixed linear model to detect an effect of the repeated time measure. Condition, Week and their interaction, were tested. The effect of each owner-dog pair was considered random. There was no significant differences between conditions, *F* (1,161.91) = 1.20, *p* = .28, weeks, *F* (3, 219.79) = 0.33, *p* = .80 or in the condition by week interaction, *F* (3, 219.79) = 0.56, *p* = .64. Considering that the data did not change significantly over time, an average walking activity in minutes for each participant was calculated and used in subsequent analyses.

The mean of the weekly walking average for 175 adopter-dog pairs was 243.66 min (*SD* 208.74) with a range of 18-1260 min reported; the median was 186.75. Upon visual inspection of the data, four owners' reported average weekly values were beyond three standard deviations above the mean (> 869.88 min). These cases, two in control (917 min) and two in the intervention (1064 and 1260 min), were removed from analysis.

The revised weekly walking mean for adopters with their dogs was 225.04 min (*SD* 169.95) with a median of 183.75 min.

A multiple linear regression analysis with backward elimination was then used to identify whether experimental condition; the age or weight of the dog; number of dogs in the household prior to adoption; first-time ownership; age, race, highest education level achieved or annual income of the adopter; dog walk attendance; Component loading 1 (obligation & walking self-efficacy) or 2 (dog's behavior on-leash), or return of the dog, significantly predicted the average weekly walking activity of the adopter-dog pairs. Four variables, Component loading 1, adopter's race (Native American and Other), and number of other dogs already in the home, remained in the equation and accounted for 21.7% of the variability in the extent of adopters' average walking activity: $F(4,130) = 10.27$, $p < .001$. Table 4-2 presents the all variables model and the model with the four remaining variables.

We found that Component 1 significantly predicted walking activity ($\beta = -59.00$, $p < .001$). The range of Component 1 values was -1.14 to 5.47. To simplify interpretation of these values from the PCA, the intercept was adjusted to reflect the Likert scaling (1-7) used in Component 1 answers. The scaled regression equation predicting average weekly walking minutes was $y = 360.90 – 59.00x$. Thus, we find that for every 1-unit increase in the Component 1 loading, walking activity decreased by 59 min. For example, a response equivalent to an answer of Agree (2) increasing to a response equivalent (3) Neutral would decrease average walking activity from 242.90 to 183.90 min.

Owners who identified their race as Native American (β = 266.84, $p < .01$) and Other (β = 119.84, $p < .06$) were found to be significantly and marginally predictive, respectively, of average walking activity above and beyond White/Caucasian adopters. However, given the limited number of adopters who indicated Native American (3) or Other (7) in the baseline survey, we did not interpret these results further. We did find that having other dogs in the home trended toward significance (β = -21.62, $p < .08$). This would suggest that for every dog in the home in addition to the adopted dog, average walking activity decreased by 21.62 min.

A logistic regression analysis with backward elimination was employed to ascertain whether experimental condition; age or weight of the dog; number of dogs in the household (in addition to the adopted dog); ownership status; age, race, education or income of the adopter; weekly walking activity, group dog walk attendance, or either component loading predicted a dog's return to the shelter. A test of the full model against a constant only model was not statistically significant.

Discussion

Our hypothesis, that adopters in the intervention group would be more active with their dogs and subsequently return these dogs less often than adopters in our control group, was not supported. However, average weekly walking activity of dog-adopter pairs was predicted by their reported sense of obligation and dog walking self-efficacy. These results support findings from previous research on likely motivators for owner-dog walking (Hoerster et al., 2011; Richards, McDonough, Edwards, Lyle, & Troped, 2013) and also suggest that providing educational interventions to new adopters in hopes of strengthening this bond and reducing relinquishment is more multi-faceted than can be accounted for with any simple hypothesis. Although previous research has identified risk factors associated with failed ownership (Patronek et al., 1996; Salman et al., 1998; New et al., 2000; Diesel et al., 2008) to our knowledge there have been no validated post-adoption interventions that systematically reduced the number of adopted dogs returned to the shelter.

In our study, adopters who received weekly behavioral advice and encouragement to exercise for four weeks post-adoption did not return their dogs less often than adopters in the control condition that received general adoption information. Adopters that opted out of the study and did not return calls or emails to participate during the enrollment period, thus not receiving any information from researchers, did have a slightly higher proportion of failed adoptions than adopters who returned at least one survey (6.7% versus 5.5%). At first glance, these return rates appear to be substantially lower than AAWL's 2013 return rate of 13.7% (PetPoint, June 2014), which is consistent with previous shelter relinquishment research. However, the 13.7% includes all dogs returned in 2013 regardless of the year in which they were adopted. The return rate just for dogs adopted in 2013 and returned within the same year was 6.3%.

The median weekly walking average reported by owners during our study (186.75 min) was slightly higher than, but consistent with, the median duration found in Christian et al.'s (2013) review of dog ownership and physical activity (160 min). It is worth noting that these amounts likely reflect an over-reporting bias (Sallis & Saelens, 2000), and may not represent the actual duration of activity undertaken by the owner with his or her dog.

Placing accelerometers on both adopters and their dogs would address this concern. However, considering the novelty of the relationship, new dog adopters may walk their dogs more during the initial weeks post-acquisition than more established owner-dog pairs. Adopters who reported more obligation and self-efficacy in walking their dogs did in fact walk their dogs for longer each week, regardless of treatment condition. This was also reported by Hoerster et al. (2011), which found that owners who walked their dogs (versus those that did not) reported higher obligation towards their dogs and more dog walking self-efficacy.

More minutes of walking each week was not correlated with a reduced likelihood of return to the shelter. In fact, neither obligation, walking self-efficacy, nor perceptions of their dogs' behavior on-leash was related to the intervention or whether adopters were more or less likely to return their dogs to the shelter. It is possible that walking on-leash, though clearly one activity that owners and their dogs can share, may not alone be determinative of the strength of the human-animal relationship. Instead, quality of time spent together in a shared activity may be more influential (Dotson & Hyatt, 2008). While most adopted dogs in Marston et al. (2005) were exercised each day, it was observed that dogs receiving less than 10 min of petting each day were relinquished more frequently back to the shelter.

We did observe a trend that as the number of dogs in the household increased, less time was spent walking with the adopted dog. Similarly, Degeling and Rock (2013) described owners' inability to control multiple dogs on-leash as a barrier to physical activity with them, and quantitative research from Westgarth, Christian, and Christley

(2015) identified that having multiple dogs in the home was negatively associated with owners walking daily with their dogs. Nevertheless, other studies (Cutt, Giles-Corti, & Knuiman, 2008; Degeling, Burton, & McCormack, 2012) have shown that owning multiple dogs did not affect whether owners walked their dogs or met certain weekly walking criteria. It may be that including the number of dogs when examining minutes of weekly activity, as was done in our study and in Masters and McGreevy (2008), may be more powerful in detecting such an effect (Aiken, West, & Reno, 1991). Furthermore, the presence of a backyard to the home might have also contributed to the variability in walking times. Scheibeck, Pallauf, Stellwag, and Seeberger (2011) found that owners with a backyard walked their dogs for less time than owners without such a facility.

Of adopters enrolled in our study, only 12.6% of those in the intervention attended at least one weekly group dog walk. These walks were led by positive reinforcement dog trainers and held in park-like locations throughout Phoenix, AZ, in areas most often indicated in AAWL adoptions the previous year. We were surprised by the lack of utilization of this training resource given suggestions of its possible impact on relinquishment (Patronek et al., 1996; Salman et al., 2000; Wells & Hepper, 2000; Diesel et al., 2008), particularly when offered for free or at low-cost to adopters (Shore et al., 2008). However Kogan, Ruch-Gallie, and Salman (2000) also found that new owners failed to utilize training resources post-adoption despite their cost-free accessibility.

Attendance at trainer-led group dog walks in our study was not related to adopter walking activity or returns at the shelter. Similarly, Kwan and Bain (2013) found that surrendering owners were just as likely to have attended training classes as owners who did not relinquish their dogs to the shelter. In fact, Pirrone et al. (2015) found no effect of dog training on reported behavioral problems. In Coren (1999), only 24% of dog owners had attended obedience classes; and when Bennett and Rohlf (2007) surveyed owners who were particularly committed to their dogs, half of these owners never or rarely attended any type of training with their dogs. Involvement in training activities did, however, predict a decreased incidence of reported behavioral problems. Taken together, this could suggest that when owners seek out training it could be related more to addressing existing behavioral problems and less to prevention or general education. If owners did not perceive any notable behavior concerns during the first month of adoption, this could explain the lack of attendance at the trainer-led dog walks.

Another possible explanation may involve the locations of the weekly group dog walks. While considerable effort was made to identify locations that would be convenient to adopters, the Phoenix-Mesa-Scottsdale metropolitan statistical area is nearly 15,000 square miles (Maricopa Association of Governments, 2015). As such, it is likely these central locations were not reasonably accessible to adopters in outlying areas and contributed to the low adopter participation. Considering that the majority of owners enrolled in the study adopted their dogs at the shelter’s main campus, an improvement upon the current study may be to conduct these walks in the vicinity of this familiar location to increase attendance.

As described in other studies, providing behavioral information and counseling has met with mixed success in its impact on new owner behavior. Weng, Kass, Chomel, and Hart (2006) reported return rates in Taiwanese dog owners who were given written materials about pet care, methods to reduce unwanted behavior, and the benefits of sterilization. In follow-up phone interviews, they found that, while most owners used the materials provided, they returned their dogs more often in the first four months of ownership than those in the control group (a trend that reversed after four months). Herron, Lord, and Husseini (2014) provided adopters with five minutes of pre-adoption counseling, written materials, and a food-dispensing toy in an intervention to prevent separation-related problem behaviors. The authors found that while owners likely complied with recommendations, this did not affect the presence of separation anxiety in the home. However, Herron, Lord, Hill, and Reisner (2007) found that when owners were provided with a similar-length session of housetraining counseling during adoption, significantly more owners reported housetraining success one-month post-adoption than owners who did not receive such information.

When programs have been successful in reducing shelter relinquishment and returns, their focus has not been exclusively on providing post-adoption support as carried out in our study. Instead, in Mohan-Gibbons, Weiss, Garrison, and Allison (2014), foster homes provided care for dogs available for adoption, but were also responsible for promoting and placing them into their new homes. Mohan-Gibbons et al. (2014) found that return rates were lower for these dogs compared to dogs adopted at the shelter. It is possible that the information gathered in the foster home and adopter interactions with these dogs outside of the shelter environment may have contributed to the higher adoption success. When White, Jefferson, and Levy (2010) implemented a sterilization program in targeted areas of Austin, Texas, the authors found that while shelter intake continued to increase, the rate of that increase was slower for zip codes where the program was implemented. Furthermore, the proportion of the shelter's intake that were puppies was significantly higher from control zip codes compared to program areas.

When training has shown an effect post-adoption, those benefits have been dependent on the age of the dog. Duxbury, Jackson, Line, and Anderson (2003) reported that owners of puppies that attended the shelter's socialization classes kept their dogs more often than owners that had attended socialization classes elsewhere or did not attend such classes. Puppies were adopted between 5-10 weeks of age and attended classes from 7-12 weeks of age. However, no difference was observed in owner retention when dogs attended training after four months of age. In all, these studies seem to suggest that shelter-based interventions focused on specific at-risk owner populations in the community and puppy adopters who are particularly receptive to owner education may yield the most benefits. However, further research is needed to understand more about new owners and their dogs in the first month after adoption. In our study, we found no relationship between age of the dog or attendance at trainer-led dog walks and returns to the shelter.

An added complication in this domain is that it is difficult to accurately study shelter dog returns at individual study sites as not all owners return dogs to the shelter from which they were acquired. Weiss et al. (2014) found that owners had explored other options for re-homing such as with friends and family, other rescues and adoption organizations, and placing the dog on their own, before relinquishing to the shelter. It is possible that some adopters re-home or relinquish dogs other than back to the shelter they were adopted from. In an effort to better capture actual ownership of adopted dogs, future studies utilizing participating dogs' microchip information and coordinating with multiple shelters in the metropolitan area of interest may be able to address this concern. A low-cost option, such as utilizing SMS (short message service), could lead to more participation by increasing the ease in which adopters receive information and report their ownership status. Newell and Beyer (2012) found that chiropractic patients who received follow-up messages via SMS were over six times as likely to report they completed their prescribed at-home exercises than those that didn't receive such communication.

A limitation in our study is that although all owners who adopted dogs from AAWL were contacted multiple times, only owners interested in participating (which involved completing weekly surveys) were enrolled. Owners who opted out during our enrollment phone calls or did not return contact with researchers did not have data collected. Thus, while we were able to achieve random assignment into conditions, it is likely we did not have a random selection of adopters. Given the slightly higher return rate by adopters not enrolled in the study, it would be worthwhile to develop investigations that could possibly reach these owners. In addition to the aforementioned mobile messaging, another method to increase participation may be having shelter staff enroll owners at the time of adoption. Additionally, offering incentives to adopters for continued participation could improve an intervention's impact, particularly among adopters with lower incomes. Considering that adopters with household incomes under $50,000 comprised nearly 40% of our sample and the importance of cost in owners' decisions to relinquish dogs (Weiss et al., 2014; Dolan, Scotto, Slater, & Weiss, 2015), providing credit towards training classes, purchases at the shelter's supply store, or services at their subsidized clinic may be valuable reinforcers for their involvement.

Conclusion

In this study, providing adopters with dog behavior and human activity advice along with invitations to join a dog walking group did not increase average weekly activity of owners nor reduce the likelihood that they would return their dogs to the shelter. While access to low-cost behavior resources for dog adopters is often cited as a means to reduce relinquishment, the lack of utilization of the trainer-led walks seems to suggest otherwise. Nevertheless, adopters who reported higher obligation and self-efficacy in walking their dogs were more active with them. It is likely that the number of dogs in a household negatively impacts owners' activity with a new dog, but additional research is needed to fully understand this effect. Future studies aiming to understand more about the dog-adopter relationship post-adoption would benefit from incorporating ubiquitous technologies to deliver and record information, and possibly focusing these interventions on at-risk populations of both people and dogs for maximum effect.

SECTION 3

SHELTER DOG WELFARE

CHAPTER 5

REVIEW OF THE LIVES OF DOGS IN ANIMAL SHELTERS

In this chapter, I will review the life of dogs in animal shelters as it relates to how we measure dog welfare under these conditions; what interventions have previously been attempted to improve welfare; and what physiological, behavioral, health, and cognitive measures have been employed in these studies to address their research questions.

Each year, millions of dogs enter animal shelters in the United States (ASPCA, 2018). Considerable efforts have been made to improve outcomes for these dogs (Protopopova and Gunter, 2017), resulting in substantial increases in the number of dogs adopted and returned to their owners in recent years (ASPCA, 2018). With these gains in adoption success, the amount of time dogs reside in shelters is likely increasing (Protopopova, 2016). As the role of the animal shelter changes from one of temporary holding to longer lengths of stay (Barrett and Greene, 2015), it is imperative we decide how best to measure welfare and how use those outcomes to test evidence-based interventions intended to improve the living conditions of dogs in shelters.

Despite the public's interest in companion animals, animal shelters in the United States operate under a minimal amount of federal or state regulation; consequently, dogs' experiences can vary considerably between facilities (Newbury et al., 2010). A large body of research suggests that dogs experience a variety of potential stressors at the shelter that could negatively impact their welfare (Taylor and Mills, 2007; Hennessy, 2013), including but not limited to excessive noise (Sales, Hubrecht, Peyvandi, Milligan, & Shield, 1997; Coppola, Enns, & Grandin, 2006; Scheifele, Martin, Clark, Kemper, & Wells, 2012; Venn, 2013), spatial restrictions (Hubrecht, 1995; Hubrecht, Wickens, & Kirkwood, 1995; Beerda, Schilder, Van Hooff, De Vries, & Mol, 1999) and loss of attachment figures (Hiby, Rooney, & Bradshaw, 2006). Yet the presence of these environmental conditions does not in and of itself cause stress upon the animal, as the perceived stressfulness of these conditions is dependent upon the individual experiencing them (Lazarus, Deese, & Osler, 1952).

When we consider the inherent challenges of measuring a multi-dimensional state such as welfare, it is not surprising that consensus has not been reached about how to measure it in shelter dogs (Mason and Mendl, 1993). Protopopova (2016), citing the work of Beerda et al. (1999), Hetts et al. (1992), Hubrecht, Serpell, and Poole (1992) and Denham et al. (2014), proposed the use of stereotypic behaviors to measure the effects of sheltering on dogs, with stereotypies defined as repeated movements or behaviors that serve no obvious function (Fraser & Broom, 1990), such as pacing or circling. However, in the aforementioned studies, which observed laboratory or working dogs, the incidence of repetitive behaviors was high, reaching upwards of 80-90% of dogs displaying the behaviors. Conversely when companion dogs in shelters were the research subjects (Mertens & Unshelm, 1996; Protopopova, 2016), 10% or fewer dogs displayed stereotypies, and, in some cases, spent less than 1% of their time engaged in these behaviors. Considering how minimally dogs were engaged in these behaviors in animal shelter environment, their usefulness as an indicator of welfare seems to be limited.

While one explanation is that a low prevalence of stereotypic behavior is indicative of low stress in shelter-living dogs, it is also possible that this measure lacks the sensitivity needed to capture the range of welfare states the shelter dogs are experiencing.

It's possible that behaviors more often displayed by dogs in shelters may provide greater insights into their welfare. Previous studies have suggested that increases in paw-lifting (Beerda, Schilder, van Hooff, de Vries, 1997; Beerda, van Hooff, de Vries, and Mol, 1999; Beerda, van Hooff, de Vries, and Mol, 2000; Hiby, Rooney, & Bradshaw, 2006; Rooney, Gaines, & Bradshaw, 2007), vocalizing (Hetts, Clark, Calpin, Arnold, and Mateo, 1992; Beerda et al., 1999), self-grooming (Beerda et al., 1999; Hetts et al., 1992), lip-licking (Hekman, Karas, & Dreschel, 2012; Shiverdecker, Schiml, & Hennessy, 2013), and panting (Beerda et al., 1997; Hiby et al., 2006; Rooney et al., 2007; Shiverdecker et al., 2013; Hekman et al., 2014) are related to stress levels the animal is experiencing. The challenge in interpreting the results of these studies is in their design. Many of these studies, including Beerda et al. (1997), Beerda et al. (1999), and Hetts et al. (1992), induce assumedly stressful experiences upon the animal, such as a change in housing condition, and observe their impacts on behavior or physiology. Yet such a design assumes that what we perceive as stressful is indeed stressful to the animal, and that any change in behavior between conditions is related to the stressfulness of that environmental manipulation.

Instead, a more interpretable approach would be to measure both physiological parameters and observable behavior together, allowing us to then infer with greater confidence the impact of stress on behavior. Previous attempts by Hiby et al. (2006), Rooney et al. (2007), and Part et al. (2014) have led to limited conclusions often resulting in single correlations between a behavior and physiology. Conversely, Hekman et al. (2012) successfully identified head resting, panting, and lip-licking in a hospitalized setting as predictive of salivary cortisol values. Incorporating the use of other hormones involved in the stress response system, such as adrenaline and noradrenaline (Goldstein & Kopin, 2008; Del Giudice, Ellis, & Shirtcliff, 2011; Chen, Arsenault, Napper, & Griebel, 2015), would likely improve detection sensitivity in identifying behavioral correlates of the response. Additionally, cortisol-to-creatinine ratios (C/C) have a longer reflection period (3 +/- 1 hours; Schatz & Palme, 2001) and may capture more physiological information about what the animal is experiencing.

Zoos, animal parks and others who provide environmental enrichment interventions to diverse species living in captivity, have struggled to define how welfare should be measured, what outcomes should be examined, and what interventions should be implemented (Newberry, 1995). Companion animal welfare in the animal shelter is no different. Over the past two decades, the growth of sheltering has led to a need and subsequent defining of guidelines in an effort to improve the standard of care animals receive (Newbury et al., 2010). Thus, the use of behavioral interventions designed improve the welfare of shelter-living dogs have become much more commonplace (Weiss, Mohan-Gibbons, & Zawistowski, 2015, Protopopova & Gunter, 2017). These interventions can be broadly categorized into those that provide social interaction: either human or conspecific, object enrichment, sensory stimulation: auditory, visual, and olfaction, or diet modification.

The most commonly studied enrichment provided to shelter dogs to improve their welfare is in- or out-of-shelter interactions with people (Hennessy, Davis, Williams, Mellott, & Douglas, 1997; Hennessy, Williams, Miller, Douglas, & Voith, 1998; Hennessy et al., 2002; Coppola, Grandin, & Enns, 2006; Hennessy, Morris, & Linden, 2006; Normando et al., 2009; Bergamasco et al., 2010; Menor-Campos, Molleda-Carbonell, & Lopez-Rodriguez, 2011; Shiverdecker, Schiml, & Hennessy, 2013; Fehringer, 2014; Dudley, Schiml, & Hennessy, 2015; McGowan, Bolte, Barnett, Perez-Camargo, & Martin, 2018). A consistent design feature across all studies is removing the dog from the kennel and introducing human interactions in small rooms or living room-like settings (Tuber, Sanders, Hennessy, & Miller, 1996). One-time, in-shelter interactions, such as those described in Hennessy et al. (1997), Hennessy et al. (1998), Menor-Campos et al. (2011), Shiverdecker et al. (2013), and Dudley et al. (2015), involve interactions of 20-30 minutes that use petting or play, and test the impact of these interventions on cortisol levels. Although the sex of the human or ease of the dog with the human can alter the impact of the petting (Hennessy et al., 1997; McGowan et al., 2018), these interventions provide temporary reductions in stress levels as assessed through cortisol.

Recently, a shorter interaction time, 15 minutes, was found to decrease heart rate, increase heart rate variability, and reduce standing (during the session) with no changes in cortisol (McGowan et al., 2018). Protopopova, Hauser, Goldman, and Wynne (2018) observed that 15 minutes of out-of-kennel exercise with a volunteer influenced dogs' in-kennel behavior, resulting in decreases in back-and-forth motion, jumping on the kennel door, and wall rubbing; and fifteen minutes of calm interaction also lead to reduced jumping on the kennel door as well as barking but increased back-and-forth motion. A previously unexamined outcome measure in human-dog interactions in the shelter is serotonin, a neurotransmitter implicated in mood and cognitive regulation. Alberghina, Rizzo, Piccione, Giannetto, & Panzera (2017) found serotonin levels correlated with dogs' social behavior when interacting with a new person during a walk and play session.

Longer, one-time interactions of 45 minutes (Coppola et al., 2006) that included petting, play, and grooming produced one-time reductions in cortisol values when measured the following day. Shorter interactions that occurred multiple times a week for several weeks, such as reported in Bergamasco et al. (2010), led to reduced cortisol, increased heart rate variability, and improved behavioral scores, such as sociability, at various time-points throughout the study when compared to controls. Normando et al. (2009), reported that 15-minute, weekly interactions over several weeks led to dogs changing their position more to the front of the kennel with increases in tail wagging, although no physiological stress response measures were taken. Hennessy et al. (2002) tested 20-minute interactions occurring several times a week over eight weeks, coupled with dietary changes, and found that while cortisol levels decreased after a couple weeks of the intervention, reductions in ACTH, a hormone involved in the stress response of the HPA axis, did not decrease until the final week, and only for those dogs that had been fed a higher-quality diet.

Wells and Hepper (2000) found that dogs seeing a person visible from their kennel resulted in increased standing, barking, and being at the front of the kennel compared to a control condition. Prohibiting the presence of potential adopters in the kennel environment has been shown to reduce kennel noise, increase sedentary and locomotor behaviors, and reduce stereotypies (Hewison, Wright, Zulch, & Ellis, 2014). However, there was no change in cortisol levels before and during the intervention.

The effects of another type of social interaction, training, have been investigated in shelter dogs. Thorn, Templeton, Van Winkle, and Castillo (2006) found that in short training sessions, dogs can readily learn a new behavior (sit), perform it with new people; and anecdotally, such training can lead to reductions in behaviors such as barking, spinning, pacing, lunging, and jumping on the kennel however the effect behavior needs further empirically measured. Herron, Kirby-Madden, & Lord (2014) provided in-kennel training sessions over the course of three days and found that training increased sitting and lying down behaviors and reduced barking and jumping when baseline and post-treatment levels were compared. Protopopova and Wynne (2015) demonstrated that both classical and operant conditioning can reduce undesirable in-kennel behaviors, including barking, by 88 and 66 percent, respectively. In a follow-up study, Payne and Assemi (2017) also investigated a simple pairing of a door chime and food and its effect on the barking behavior of shelter dogs, and found that 45 pairings for each dog over the course of three weeks led to a 15 dB reduction in noise in the kennel.

Human interactions, such as those described by Hennessy et al. (2006) and Fehringer (2014), in which the dog leaves the shelter temporarily for few days or weeks may provide an increased welfare benefit to dogs when compared to social interactions where the dog remains at the shelter. Hennessy et al. (2006) found that when prisoners fostered dogs for a three-week socialization program, the dogs were observed, post-intervention, to jump and bark less, yawn more, and more readily respond to training cues; however cortisol measures were unaltered. Most promising, Fehringer (2014) reported that placement in a foster home lowered shelter dogs' cortisol compared to in-shelter values, and that the dogs' cortisol concentrations steadily declined over the first three days of foster care.

Researchers have also examined the effects of interaction with other dogs, either through housing manipulations (Mertens & Unshelm, 1996 and Wells & Hepper, 1998) or supervised interactions out of the kennel (Flower, 2016). Mertens and Unshelm (1996) measured behavioral differences in individually and group-housed dogs and found that housing dogs together led to reductions in noise and improved behavior with people. Group-housed dogs were also not observed displaying stereotypic behaviors compared to 10% of dogs that were singly housed. The ability to see other dogs as provided in Wells and Hepper (1998) was found to alter dogs' kennel position without changing activity or vocal behavior. Walker et al. (2014) reported that when pair-housed shelter dogs were separated and singly-housed, dogs experienced behavioral and physiological changes with increased running, pacing, stretching and grooming and elevated s-IgA levels, a salivary antibody involved in immune function. However, no differences in cortisol or cognitive bias, a task that measures underlying affective state, were found. Outside of the kennel, providing dogs opportunities to interact with other dogs has been shown to improve dog social skills when behaviorally assessed after these interactions (Flower, 2016). Thus from these studies, we can conclcude that dogs do benefit behaviorally from opportunities to live and interact with other dogs in the shelter.

Investigations into the benefits of object enrichment on the behavior of shelter-living dogs have been met with mixed success (Wells & Hepper, 2000; Wells, 2004; Kiddie, Bodymore, & Dittrich, 2017). When dogs were provided with a toy or bed (Wells & Hepper, 2000), they spent more time at the front of their kennels when a bed was there but no other changes were observed in their activity or vocalization behaviors. Wells (2004) found providing toys (a variety of balls, a chew, and a rope) resulted in surprisingly little engagement from the dogs (< 10% of the time) and reduced over the observation period; although when dogs did engage with the toys, they spent more time moving and less time standing in their kennels. When beds and coconuts were provided to fighting dogs (Kiddie et al., 2017), yawning, time spent lying down, and sitting in-kennel decreased.

Auditory stimulation, such as music and audiobooks, appears to change the behavior of shelter dogs (Wells, Graham, & Hepper, 2002b; Kogan, Schoenfeld-Tacher, & Simon, 2012; Bowman, SPCA, Dowell, & Evans, 2015; Brayley & Montrose, 2016; Bowman, Dowell, Evans, & SPCA, 2017). One particularly well-studied musical intervention is classical music. Wells, Graham, & Hepper (2002b) found that exposure to classical music reduced in-kennel barking; and Kogan et al. (2012) also found that classical music led to dogs sleeping more and vocalizing less. Both studies observed detrimental behavior effects with heavy metal music, including increased barking and body shaking. When two-hours of auditory enrichment was tested in Brayley and

Montrose (2016), dogs spent more time resting and less time sitting or standing when listening to an audiobook recording compared to other music (i.e., classical, pop, “Through a Dog’s Ear,” or a control condition.

Weeklong auditory interventions, such as those implemented in Bowman et al. (2015) using multiple welfare measures – heart rate variability, cortisol, and behavior – found that, in a cross-over design, both silent controls and classical music showed increases in dogs’ heart rate variability. Dogs were also sitting and lying down more with less time standing and barking; however no changes in cortisol were reported. Interesting, Bowman et al. (2015) identified a possible habituation effect to the music in as little as two days of exposure. When Bowman et al. (2017) tested multiple genres of music (i.e., pop, soft rock, reggae, Motown, and classical) using similar outcome measures, they found that dogs spent more time lying and less time standing in their kennels, regardless of genre; and dogs’ barking increased after the auditory enrichment ceased. Heart rate variability increased across all genres, although it differed in the magnitude of effect. Cortisol levels were found to be higher during soft rock music and during post-treatment silent controls.

Only a few studies have explored providing olfactory enrichment to shelter dogs and observing their effect on behavior. Graham, Wells, and Hepper (2005) found that exposure to odors like lavender and chamomile led to decreases in vocalizations and increased resting; however when dogs were exposed to rosemary and peppermint, their activity in-kennel increased, with more standing, moving, and vocalizing. When dog-appeasing pheromone was diffused throughout the kennels over seven days by Tod, Brander, & Waran (2005), they found that barking amplitude and frequency decreased in the kennel with dogs showing more resting and sniffing behaviors and less barking when approached by a friendly stranger in their kennel.

In this review, I have attempted to describe the interventions thus far employed to improve the lives of dogs in shelters with a special focus on the outcome measures used to test these research questions. In the upcoming chapter, my objective was to describe one intervention, temporary stays away from the shelter, and its effect on urinary cortisol levels of dogs living in five animal shelters across the country. In Chapter 7, I will explore the use of multiple measures of physiology, health and cognition in an attempt to identify behavioral indicators of welfare of shelter-living dogs.

SECTION 3

SHELTER DOG WELFARE

CHAPTER 5

EVALUATING THE EFFECTS OF A TEMPORARY FOSTERING PROGRAM ON SHELTER DOG WELFARE

Over three million dogs enter animal shelters annually in United States. Many will find new homes or return to their owners, but over 20% of these dogs will be euthanized (ASPCA, 2018). While the number of dogs arriving at animal shelters is declining as well as those that are ultimately euthanized, lengths of stay in the shelter are likely increasing as dogs await adoption (Protopopova, 2016). As such, shelters are becoming less like temporary ports in the storm for homeless pets and more akin to child orphanages (Barrett & Greene, 2015).

Within the novel environment of the shelter, dogs experience a variety of potential stressors upon entry and during their stay, including disruptive sounds, restriction of movement, and loss of social attachments (Taylor & Mills, 2007). Previous research has found that noise levels in shelter kennels can reach and exceed 100 dB (Sales et al., 1997; Coppola et al., 2006; Scheifele et al., 2012; Venn, 2013), surpassing the 90 dB limit set for human exposure set by the Occupational Safety and Health Administration for an eight-hour period (United States Department of Labor, 1983). Scheifele et al. (2012) found that six months of exposure to 100 dB and over of noise at the animal shelter resulted in hearing loss for all dogs measured within the study.

Dogs in homes spend much of their day in sedentary activities and are active in moderate to vigorous physical exercise for small portions of the day (Morrison, Penpraze, Beber, Reilly, & Yam, 2013). The space allowed dogs in animal shelters is likely inadequate to meet their basic activity needs (Hubrecht et al., 1995). In addition to the inhibition of free movement due to kennel size, shelter living also limits dogs' ability to interact with other canines as they are often housed singly to prevent injury and disease (Hubrecht, 1995); yet this social isolation is likely detrimental to their welfare (Beerda et al., 1999). It has been suggested that a stay at an animal shelter may be one of the most socially-isolating new experiences a companion dog may face in its lifetime (Hennessy et al., 1997).

Beyond the limitations of companionship, space and excessive noise, life in the shelter often results in dogs having little control over their daily lives, particularly contingencies surrounding interactions with other dogs and people (Hennessy et al., 1997). This lack of control may be a source of apathy-like behavior, wherein dogs display less interest towards shelter visitors over time (Wells and Hepper, 1992) and remain in the back of the kennel (Wells et al., 2002). Similarly, the lack of predictability within the shelter environment can also have a psychological impact, such as the uncertainty related to routines, like leashed walks or mealtimes (Hennessey et al., 1998). Perhaps indicative of these many limitations upon their living conditions, previous research has found elevated cortisol levels of dogs housed in shelters compared to those living in homes (Sandri, Colussi, Perrotta, & Stefanon, 2015; Dudley et al., 2015).

Welfare interventions carried out at the shelter have demonstrated that spending time with humans reduces canine stress. Menor-Campos et al. (2011) reported that just 30 minutes of walking and interaction decreased cortisol levels of shelter dogs and improved behavioral scores. Regardless of activity, be it petting, play, or simple presence in the same room, human interaction improved the welfare of shelter dogs when compared to remaining in or being removed from the kennel but without a person present (Shiverdecker et al., 2013). While the benefits of these interventions, such as reductions in cortisol, are often lost when dogs return to their kennels, researchers have speculated that longer periods of interaction with people would likely have increased benefits for shelter dogs (Coppola et al., 2006).

Little is known about how temporarily leaving the sheltering environment could improve the welfare of dogs awaiting adoption. Prior studies investigating the effects of temporary and trial adoptions (Normando et al., 2006) as well as programs that utilize foster homes to facilitate adoption (Mohan-Gibbons et al., 2014) found that dogs that participate in these programs are returned less frequently by their new owners. Additionally, adopters in Mohan et al. (2014) reported that they more often used information provided by foster families, as compared to shelter staff, in their adoption decision-making. In the present study, we hypothesized that brief stays of one to two nights in a foster home would result in lower urinary cortisol: creatinine (C/C) ratios for dogs awaiting adoption as compared to ratios collected before or after their stays. Additionally, we collected behavioral information provided by the shelter staff, foster home volunteers, and new owners after adoption in order to learn which behaviors and situations were most predictive of the dog's behavior in its new home six months after adoption. Analysis of that data will not be included here and instead will be forthcoming in a future publication.

Methods

Shelters

We collected data on the impacts of brief sleepovers at five U.S. animal shelters: Best Friends Animal Sanctuary (BFAS; May-June 2016), Arizona Humane Society (AHS; January-March 2017), the Humane Society of Western Montana (HSWM; May 2017), DeKalb County Animal Services (DCAS; June 2017), and the Society for the Prevention of Cruelty to Animals of Texas (SPCATX; July 2017). The shelters varied in their geographical location, size, admission type, and annual dog intake. BFAS located in Kanab, UT, is a limited-admission animal shelter and sanctuary, which brought 743 dogs into its care in 2016. Arizona Humane Society (AHS), an open-admission facility in Phoenix, AZ, had a canine intake for 2017 of 6,607 dogs. HSWM in Missoula, MT, is a limited-admission animal shelter with an annual intake of 847 dogs in 2017. DCAS operated by Lifeline Animal Project in Decatur, GA is an open-admission municipal facility with a 2017 intake of 5,686 dogs. SPCATX is a limited-admission animal welfare organization in Dallas, TX, which brought into its care 4,818 dogs in 2017.

The staff at each shelter determined which dogs participated in the study, and foster homes met all shelter requirements prior to fostering. Thus, we did not intercede on organizational decisions regarding which dogs were temporarily fostered, requirements for volunteers fostering dogs, or the shelter's expectations while dogs were in the care of fosterers.

Sleepovers

Dogs were temporarily fostered for one (BFAS) or two nights (all other shelters). Foster volunteers picked up dogs from the shelter where staff provided them with fostering instructions and supplies. The authors discussed the purpose of the study and instructions for urine collection and completing the behavioral questionnaire. When the dogs returned to the shelter following the sleepover, the authors met with foster volunteers, collected urine samples and the questionnaires, and dogs were returned to their kennels.

Urine Collection

Urine was collected before, during, and after sleepovers for C/C analysis. For dogs at BFAS, the authors collected baseline and post-sleepover urine samples in the shelter the morning before and after, respectively, the dog was temporarily fostered. The fosterer collected the urine sample on the morning after the sleepover before returning the dog to the shelter. This resulted in three collection time-points for each dog at BFAS. For all other shelters, dogs had two days of baseline, sleepover, and return-baseline. Urine was collected the morning before the day of the sleepover and the morning prior to sleepover. Fosterers collected urine the mornings after the first night and second night of the sleepover before returning the dog to the shelter. In total, six time-points were collected with each dog at AHS, HSWM, DCAS, and SPCATX.

Samples were collected using Olympic Clean-Catch™ plastic trays taped to 36-inch (91-cm) “Pickup and Reach” tools (Harbor Freight, Calabasas, CA). After collection in the tray, samples were poured into 10 mL plastic conical bottom centrifuge tubes with screw caps for storage. Collection trays were rinsed with water prior to use. Fosterers were provided with urine collection kits, including a “Pickup and Reach” tool with taped plastic trays and labeled storage tubes.

For shelter urine collection pre- and post-sleepover, the authors removed dogs from the kennel and walked them on-leash to an approved outdoor location for elimination. After urine collection, dogs were returned to their kennels. Urine samples were collected between 7:00 am and 9:30 am, immediately placed in a cooler with ice, and in a freezer within two hours. Five percent of samples fell outside this collection range due to dogs not urinating when walked or not providing an adequate volume of urine (minimum 1.5 mL). In these cases, dogs remained with the authors and were provided a mixture of wet food and water before another attempt at urine collection was made. Foster volunteers were instructed to collect urine upon the dog’s waking when given their first elimination opportunity. Urine samples brought to the shelter by fosters within 30 min of collection were typically not cooled or frozen until arrival at the shelter. Fosterers whose samples arrived 30 mins after collection (i.e., first morning collection at AHS, HSWM, DCAS, and SPCATX) were instructed to freeze these samples until transport to the shelter. As with shelter urine collection, storage tubes were immediately placed in a cooler with ice, then placed in a freezer until shipment. Time of collection was noted for each sample.

Frozen urine samples were shipped overnight on dry ice to Animal Reference Pathology (Salt Lake City, UT, USA) for C/C analysis. Analysis occurred within one month of sample collection. Analysis was conducted using an automated wet biochemistry analyzer (Dimension Xpand Plus, Siemens Healthcare Diagnostics Inc., Newark, DE, USA) for the measurement of creatinine. Human (Urine) Precision Control 2 and 3 Chemistry Controls (Randox Laboratories Limited, Crumlin, County Antrim, UK, Control level 2 #UN1557, Control level 3 #UE1558) were run on each day of testing urine samples. These two levels of control were reconstituted and stored according to manufacturer instructions.

Cortisol was measured using a commercially available product designed for an enzyme-amplified chemiluminescence assay system (Immulite 1000, Diagnostic Products Corporation, Los Angeles, CA, USA). Cortisol: creatinine ratios (measured in μmol/l: μmol/l) $\times 10^{-6}$ were then calculated.

Health-Monitoring Collars

At AHS, HSWM, DCAS, and SPCATX, health-monitoring collars (PetPace, Shefayim, Israel) collected dogs' temperature, pulse, respiration, activity, and positions through the use of acoustics, 3-D accelerometer, and thermistors. Once collected, data was transmitted via ultra high frequency radio to nearby internet-connected base units, which sent information to PetPace online data portals for analysis. For the purposes of this study, average pulse rates while the dogs were at rest, longest bout of uninterrupted rest, and proportion of resting activity (out of total activity measured) for the three aggregate time-points (before, during, and after sleepover) were calculated for each dog.

Statistical Analysis

Using data collected at BFAS, multiple linear regression analyses with backward elimination were employed to determine whether urinary C/C values could be predicted from dogs' sex, age, weight, length of stay, number of previous sleepovers, days since last sleepover, or location of sleepover (on-site in BFAS lodging or off-site, this is the only shelter that allowed on-site accommodation of dogs and fosterers). To test whether these cortisol values changed between collection times, we analyzed C/C ratios with a mixed linear model. Dog and intercept were entered as random effects with time-point and the covariates of length of stay and number of previous sleepovers included as fixed effects in the model. Restricted maximum likelihood estimation (REML) and diagonal covariance matrices were used.

With cortisol and creatinine analyses conducted on the urine samples of dogs from HSWM, DCAS, and SPCATX, values for the six time-points were utilized in the statistical analyses. Individually with each shelter's data, multiple linear regression analyses with backward elimination were conducted to determine whether urinary C/C values could be predicted from dogs' sex, age, weight, length of stay, average resting pulse, or resting activity. To examine whether cortisol values changed from the shelter and foster home, we analyzed C/C ratios with a mixed linear model. Dog and intercept were entered as random effects with time-point and covariates included as fixed effects in the model. REML and diagonal covariance matrices were used. Mixed linear modeling was conducted with the data from each site and in aggregate with all shelters.

In our multi-shelter analyses, aggregate data from AHS, HSWM, DCAS, and SPCATX was used in a multiple linear regression analysis with backward elimination to uncover whether these urinary C/C values could be predicted from dogs' health-monitoring collar data, sex, age, weight, and LOS. Aggregate data from all five study sites was utilized in a mixed linear model analysis to determine whether shelter differences could be detected from in-shelter cortisol values. Dog and intercept were entered as random effects with shelter and the covariates of weight and age included as fixed effects in the model. Restricted maximum likelihood estimation (REML) and diagonal covariance matrices were used.

Thus, statistical analyses were conducted with each shelter's data separately, aggregating across before, during, and after sleepover time-points; and with separate and aggregate time-point data across multiple shelters to understand the relationship of various dog and shelter variables to of urinary C/C values.

Results

Best Friends Animal Sanctuary

Beginning in May through June 2016, 39 dogs were enrolled at this initial study site. Of those dogs, 38 had urine samples collected at all three time-points with 11 of those dogs providing additional samples for a total of 131 samples used in our analysis. Dogs' mean C/C ratio value was 20.03 x 10^{-6} (*SD* 7.23) with a range of 5.40 - 45.00 x 10^{-6}. Cortisol values from three dogs that were greater than three standard deviations above the mean were removed from the analysis: Dog 1, 65.25 x 10^{-6} (day 1); Dog 35, 48.40 x 10^{-6} (day 1), and Dog 36, 49.04 x 10^{-6} (day 3).

More dogs in the BFAS cohort were male (61.9%). Dogs were at the shelter for 463.46 days (*SD* 594.50) on average with a median of 203.50, and had previously participated in the shelter's sleepover program an average 18 times prior to the study (*SD* 21.32), although a median of 13.18 days (*SD* 12.02) had passed since the dog's last sleepover. Most dogs in the study were taken off-site during their sleepover (73.20%). Descriptive statistics for all participating shelters and dogs are included in Tables 6-1 and 6-2.

Multiple linear regression analyses with backward elimination were used to identify whether sex, age, weight, length of stay (LOS), number of previous sleepovers, days since last sleepover, or location of sleepover significantly predicted C/C ratios. Separate analyses were conducted to account for the variables of days since last sleepover and location of sleepover as they did not apply to all three time-points within the study. In our first regression analysis, sex and LOS were removed. Weight, age, and previous sleepovers remained in the equation and accounted for 9.7% of the variability in cortisol values: F (3,124) = 5.52, p = .001 (Table 6-3).

We found that weight significantly predicted cortisol (p = .004), such that for each kilogram increase in weight, C/C decreased by 0.342. Age showed a contrasting effect: each year of age added 0.408×10^{-6} to cortisol values (p = .035). Additionally, the number of sleepovers significantly predicted cortisol (p = .033), with each sleepover reducing ratios by 0.067×10^{-6}. Further analyses using the demographic variables of sex, age, weight, LOS, and number of sleepovers in addition to days since last sleepover (analysis two) and sleep location (analysis three) did not find any additional relationships when added to the models. This analysis is included in Table 6-3.

We subsequently analyzed C/C ratios from before, during, and after sleepovers using a repeated mixed linear model to detect an effect of the repeated time measure with weight, age, and number of sleepovers entered as covariates in the model. Significant differences were found among time-point means, F (2,50.97) = 7.34, p = .002. Pairwise post-hoc comparisons using a Sidak correction indicated that dogs during their sleepovers had significantly lower cortisol when compared to measurements at the shelter before (p = .016) and after (p = .015) their sleepovers. No differences were found between shelter time-points (p = .917). Table 6-4 presents BFAS C/C means and standard deviations for each morning before, during, and after sleepover. Those values are listed under Day 2, Day 3, and Day 5 to correspond to the subsequent shelter sites' collection time-points.

Arizona Humane Society

Forty-three dogs participated in the study from January through March 2017. AHS dogs' average C/C ratio value was 39.14 x 10^{-6} (*SD* 17.66) with a range of 2.34-98.72 x 10^{-6}; the median was 37.63 x 10^{-6}. Dogs were housed at the shelter for a mean of 14.08 days (*SD* 9.34) and were more often male (67.4%). Descriptive statistics about AHS and its dogs are included in Tables 6-1 and 6-2.

A multiple linear regression analysis with backward elimination was used to identify whether sex, age, weight, or length of stay (LOS) of dogs at AHS significantly predicted their C/C ratios. As with BFAS, the variables of weight and age remained in the equation, accounting for 33.5% of the variability in cortisol: F (2,231) = 59.58, p < .001.

Weight significantly predicted cortisol ($p < .001$) such that as weight increased by one kilogram, C/C ratios decreased by 1.60×10^{-6}. Conversely, age showed an opposite influence, such that with an increase of one year, cortisol was predicted to increase by 1.09×10^{-6} ($p = .002$). Table 6-3 includes the results of this analysis.

AHS cortisol values were analyzed across collections using a repeated mixed linear model to detect an effect of the repeated time measure with weight and age added into the model as covariates. Significant differences were detected, $F(5,53.03) = 5.79$, $p < .001$. Pairwise post-hoc comparisons using a Sidak correction revealed that dogs at AHS had significantly lower cortisol on their first sleepover morning compared to the morning in the shelter before their sleepovers ($p = .016$), and the second sleepover morning as compared to both mornings in the shelter before the sleepover ($p = .011$) and ($p < .001$), respectively. Additionally, in the shelter the morning after the sleepover, dogs' cortisol values were significantly higher than in the last (or second) morning of their sleepover ($p = .048$). Table 6-4 includes the estimated marginal means of C/C ratios and standard errors at each collection time-point.

Humane Society of Western Montana, DeKalb County Animal Services, and SPCA of Texas

From May-July 2017, 40 dogs were enrolled in the study at Humane Society of Western Montana, 43 dogs at DeKalb County Animal Services, and 42 dogs at SPCA of Texas. Descriptive statistics about HWSM, DCAS, and SPCATX and its dogs are included in Tables 6-1 and 6-2, and the multiple linear regression analysis with these variables is included in Table 6-3. Estimated marginal means of C/C ratios and standard errors at each collection time-point at HSWM are presented in Table 6-4.

Multi-Shelter Analyses

To uncover whether average resting pulse rate, resting activity, longest bout of uninterrupted rest, sex, age, weight, or average LOS (i.e., mean between LOS of time-point 1 and 2) significantly predicted aggregate C/C ratios of dogs at AHS, HSWM, DCAS, and SPCATX, a multiple linear regression analysis with backward elimination was employed. The variables of average resting pulse, resting activity, longest bout of uninterrupted rest, average LOS, weight, and age remained in the equation, accounting for 30.3% of the variability in C/C ratios: F (6,400) = 30.39, $p < .001$. For every one-unit increase in dogs' average resting pulse rate, a 0.264 x 10^{-6} increase in C/C was expected ($p = .001$). The proportion of time dogs spent resting predicted cortisol values ($p = .01$), such that with each percentage increase in rest, cortisol: creatinine ratios increased by 0.117 x 10^{-6}. However dogs' longest bout of uninterrupted rest showed an opposite effect such that as the resting duration increased, C/C was predicted to decrease by 0.011 x 10^{-6} ($p = .043$).

As previously shown only at DCAS, aggregate data analysis revealed that with each day increase in dogs' LOS, cortisol: creatinine ratios were predicted to decrease by 0.057 ($p < .001$). Evidenced both in the prior analyses of AHS and SPCATX data, dogs' weight and age significantly predicted cortisol values ($p < .001$), such that with each one-kilogram increase in weight, C/C ratios increased by 0.55 x 10^{-6}; and with each year increase in age, a 1.01 x 10^{-6} increase in cortisol:creatinine was expected ($p < .001$).

With all participating shelters, aggregate cortisol values from before, during, and after sleepovers were calculated and analyzed using a mixed linear model to detect an effect of the repeated time measure with weight, age, and average LOS added into the model as covariates. Significant differences were found among these averages, F (2, 209.04) = 31.71, $p < .001$. Dogs had significantly lowered cortisol values during the sleepover as compared to before the sleepover in the shelter ($p < .001$) and after ($p < .001$), with no difference in the before and after comparison ($p = .799$). Table 6-4 presents the estimated marginal means and standard deviations for before, during, and after sleepover. Those values are listed under Day 2, Day 4, and Day 6.

Cortisol values from in-shelter collections at all five participating sites were analyzed using a mixed linear model, with weight and age added into the model as covariates, to detect any effect of shelter. With these before and after aggregate values, significant differences were observed, F (2, 39.42) = 7.14, $p < .001$. In post-hoc comparisons using a Sidak correction, dogs at BFAS were found to have significantly lower cortisol values than dogs at AHS ($p < .001$), HSWM ($p = .003$), and DeKalb ($p = .004$) with dogs at SPCATX having lower cortisol than dogs at AHS ($p = .002$). Figure 6-1 includes the estimated marginal means of average C/C ratios and standard errors for each shelter.

Discussion

Our hypothesis, that temporary fostering of shelter dogs for one and two nights in volunteers' homes would reduce stress was supported, although the magnitude of the effect varied across shelters. Adding to the literature on urinary cortisol:creatinine values, we found uniformly that dogs of greater weight had lower C/C, supporting previous findings by Zeugswetter, Bydzovsky, Kampner, & Schwendenwin (2010). With the exception of one shelter (HSWM), age was shown to influence cortisol values for dogs in our study, such that older dogs had higher cortisol, which has previously been shown in (Rothuizen, Reul, van Sluijs, Mol, Rijnberk, & de Kloet, 1993). In the four shelters in this study where health-monitoring collars were used, higher average resting pulse rates and longer time spent resting were associated with higher cortisol whereas the longest bout of uninterrupted rest was related to lower C/C values. At BFAS, where a sleepover program was in place prior to our study, the number of sleepovers a dog had previously experienced was correlated with reduced cortisol. Additionally, we were able to detect differences between shelters when comparing their average in-shelter cortisol values.

C/C ratios have been utilized in previous studies to assess the stress of kenneled and shelter dogs (Beerda et al.,1999; Hiby, Rooney, & Bradshaw, 2006; Stephen & Ledger, 2006; Titulaer et al, 2013). As a measurement of welfare, urinary cortisol provides a particularly useful reflection period of approximately two-to-four hours (Schatz and Palme, 2001) and allows for a non-invasive approach in assessing the physiological stress response of dogs. While previous studies have found elevated cortisol levels when comparing groups of dogs in homes and those in shelters (Sandi et al., 2015; Dudley et al., 2015), little is known about the effect of living condition on C/C ratios in the same dogs. Rooney et al. (2007) found that urinary C/C values of dogs entering military training kennels were not only higher than the same dogs' home values; but dogs that had previously spent time in the kennel environment in a habituation program had significantly lower cortisol than those without such experience. Accounting for differences in cortisol responding between dogs, Rooney et al. (2007) provided compelling evidence of the stress experienced by dogs when transitioning from a home to a kenneling environment.

Considering the impact of kenneling on dog welfare, only one prior study (Fehringer, 2014) has examined the effect of living condition in the opposite direction from Rooney et al., (2007); placing dogs from animal shelters into homes and measuring the physiological and behavioral effects. Ferhringer (2014) found that placement in homes lowered dogs' salivary cortisol values comparative to in-shelter values and that the dogs' cortisol concentrations steadily declined over the first three days of foster care. While saliva collection and subsequent cortisol analysis may be more sensitive to immediate stressors the dogs have experienced (Beerda et al., 1996), these results suggest that the transition and placement in a home environment is likely less stressful than shelter living.

To our knowledge, our publication is the first to examine the impact of temporary fostering on the cortisol response of dogs awaiting new homes. While adoption programs, such as those described in Fehringer (2014) and Mohan-Gibbons et al. (2014) do involve the fostering of dogs living in shelters, these programs housed dogs with volunteers until placement or study completion. Conversely, temporary fostering, or sleepovers, in this study are departures of one-to-two days with intended return to the shelter. Thus, sleepovers should be viewed primarily as a form of enrichment for shelter-living dogs.

In our analysis of dogs' heart rate and resting data, a positive correlation between resting heart rate and cortisol was found, which had previously been observed in Beerda et al. (1997), demonstrating not only the relationship between these measures but the ability of commercially available health-monitoring collars to detect these changes in dogs' biological responding. More difficult to understand is the positive relationship found between proportion of time spent resting and C/C ratio values. One explanation may be found by considering the behaviors that were likely included in this measure of rest. Activity was collected by 3-D accelerometers that are sensitive to movement. With this particular health-monitoring device, a dog could be lying down, sitting, standing or even slightly moving and still be considered resting (Asaf Dagan, personal communication, March 19, 2018). In a contemporaneous study (Gunter et al., in prep) certain postures, such as a dog lying down with its head down, was found to be associated with lower cortisol and metanephrine values, while standing was associated with higher levels. It is possible that while these collars are detecting a lack of movement by the dogs, the behaviors involved in the "at rest" measure may correspond to differing physiological states.

Conversely, dogs' longest period of rest as measured by the health-monitoring collars was not only negatively associated with cortisol responding; but the longest periods of rest were observed during the sleepovers, and rest bouts upon return to the shelter were longer than those before the sleepover. Considering that rest bouts were nearly six hours in length, on average, in the foster home, it is most likely these dogs were in sleep or near sleep states; and this measure, unlike our proportion of rest activity, was a better measure of rest because it is unlikely that dogs would remain sitting or standing for such a long period of time. Owczarczak-Garstecka and Burman (2016) found that dogs in a rescue center slept for 45% of a 24-hour cycle whereas dogs in homes have been shown to rest for 60% (Morrison et al., 2013). Our results suggest that dogs may be experiencing a sleep deficit in shelters, which may explain the longer bouts of rest recorded while in the foster home. Additionally, the longer bouts of recorded rest we measured post-sleepover are consistent with anecdotal shelter staff reports of more restful behavior displayed in-kennel by sleepover dogs upon return to the shelter.

We also noted significant differences in in-shelter cortisol values (aggregating values before and after dogs' sleepovers) at our five participating sites. While it is often difficult to compare physiological findings across disparate studies when taking into consideration differences in collection and study participants (e.g., age and weight of dogs), researchers and methods in our study were consistent across shelters and variables known to affect cortisol values were included in the analysis. Previous research by McCobb, Patronek, Marder, Dinnage, and Stone (2005) found that feline cortisol:creatinine ratios differed significantly between shelters, such that those that provided greater environmental enrichment had cats with lower C/C ratio values than cats in more traditional shelters. Considering the diversity of open- and limited-admission shelters in our study where annual intake ranged from under 1,000 to over 6,000 dogs, it is certainly possible that as yet unstudied factors, such as dog density, kennel conditions, husbandry, and/or enrichment programs could contribute to the overall welfare of shelter dogs.

Our findings here indicate that while significant physiological benefits were observed with dogs at each shelter, the shelter with the highest in-shelter cortisol values (AHS) benefited the greatest from the intervention, with nearly a one-quarter reduction in C/C ratios. Conversely, cortisol responding of dogs at the shelter with lowest baseline cortisol values (BFAS) decreased by only 12% when staying overnight in a fosterer's home. While this difference in benefit from the sleepover could be attributed to differing levels of stressors in these different shelters, other variables may play a role. It is possible had the sleepover continued for a second night, dogs from BFAS may have experienced as great a reduction as was observed at all other shelters in the study where two-night sleepovers were tested. However, the results from SPCATX, where the dogs also had lower initial in-shelter C/C ratios, experienced two-day sleepovers, and yet also showed a lessened effect of the sleepover, contradict this hypothesis.

As indicated at the shelters within our study, C/C values at the end of study enrollment were not significantly lower (or higher) than initial in-shelter values, suggesting that the benefits of the sleepover were short-lived. However, evidence from dogs at BFAS where we found a significant impact on C/C of the number of sleepovers a dog had participated in, indicate that multiple sleepovers are related to lower cortisol – although it should be acknowledged that the effect is very small in magnitude. Nevertheless while interventions such as the one described here or out-of-kennel interactions of varying length and activity (Coppola et al., 2006; Menor-Campos et al., 2011; Shiverdecker et al., 2013) may provide temporary relief for dogs in shelters, it is possible that shelter design or daily procedures may also provide sizeable benefits in stress reduction. Further investigation manipulating environmental factors between and within dogs at the same facility may elucidate their potential impact on shelter dog welfare.

One limitation in our study is that not all dogs were able to eligible for participation, particularly dogs that were not able to walk on leash for urine collection or deemed unsafe by staff at the shelters. Previous findings from Stephen and Ledger (2006) suggest that dogs displaying more fearful behavior may show higher responding in the shelter; therefore, it's possible that transitioning to a new foster environment for these type of dogs may result in elevated cortisol levels when first arriving. Additionally, urine sampling was conducted in the morning, not long after waking; and as such, cortisol levels should be viewed accordingly and not reflective of a dog's 24-hour experience in the shelter. Research by Beerda et al. (1996) has suggested morning sampling may yield higher C/C ratios compared to the afternoon, although more recent work with a larger sampling of owned dogs does not find this effect (Zeugswetter et al., 2010). Thus, it's possible a later day urine collection during our study may have found a less robust effect of living condition, particularly if shelter environment was perceptively less stressful for dogs in the evening hours.

Conclusion

This study demonstrates that shelter dogs' urinary cortisol concentrations can be systematically decreased when the dogs are placed into temporary foster homes, as compared to in-shelter values obtained prior to and after the sleepover. This reduction in stress, observed at all five participating shelters, varied in its magnitude and was lost once dogs returned to the shelter, although longer bouts of restful behavior post-sleepover did continue. These findings suggest that while a reprieve from the shelter is impactful for the welfare of companion dogs, mitigating the stressors present in kenneling conditions that are likely contributing to higher stress responding should also be addressed to improve the overall welfare of shelter-living dogs.

SECTION 3

SHELTER DOG WELFARE

CHAPTER 7

IDENTIFYING BEHAVIORAL INDICATORS OF WELFARE IN SHELTER DOGS

A high proportion of the dogs living in the United States are housed in animal shelters (more than 4% in some surveys; ASPCA, 2018). While the number of dogs euthanized in shelters has decreased and the number of dogs adopted or returned to their owners has increased, the amount of time dogs await adoption is likely increasing (Protopopova, 2016). Shelters are becoming less like temporary ports in the storm for homeless dogs and more like orphanages where stays of weeks are not uncommon (Barrett & Greene, 2015). As such, the welfare of these kenneled dogs is of increasing import to animal sheltering.

Previous research has identified many stressors in the daily lives of dogs in animal shelters, including but not limited to excessive noise (Sales et al., 1997; Coppola et al., 2006; Scheifele et al., 2012; Venn, 2013), spatial restrictions (Hubrecht, 1995; Hubrecht et al., 1995; Beerda et al., 1999) and loss of attachment figures (Hiby et al., 2006). It is widely accepted that animals under human control should be accorded the five freedoms – of which one is the freedom from fear and distress (Council, 1992).

Stress is an internal physiological and psychological state. Environmental stimuli that interrupt the maintenance of an animal's homeostasis are considered stressors (Lazurus et al., 1952), and these disrupting factors can be psychological or physical in nature (Joëls, Pu, Wiegert, Oitzl, & Krugers, 2006). The stress response system is activated in a variety of circumstances, which require individuals to be aroused, vigilant, and take action if necessary (Nesse & Young, 2000). As such, stressors can be defined as producing excessive demands to attention creating unpredictability for the animal (Mendl, 1999; Beerda et al., 2000). The activation of the stress response system is designed to restore balance through the release of various neurotransmitters, peptides, and hormones, which protect the organism and allow it to deal with potential threats (McEwen, 2000).

Activation of the stress response system is hierarchal with initial engagement by the parasympathetic (PNS), then the sympathetic (SNS) nervous systems, followed by the hypothalamic-pituitary-adrenal (HPA) axis. If engagement of PNS cardiac arousal is not sufficient to cope with the environmental challenge (Porges, 1995), activation of the SNS mediates an animal's flight-or-fight response with the release of epinephrine (E) and smaller amounts of norepinephrine (NE) (Goldstein & Kopin, 2008; Del Giudice et al., 2011; Chen et al., 2015). When stressors trigger engagement of the hypothalamic-pituitary-adrenal (HPA) axis, cortisol is introduced into systemic circulation within the body (Conrad, 2011).

Cortisol is one of most widely used physiological markers of the stress response in dogs (Hewson, Hiby, and Bradshaw, 2007). Previous studies comparing cortisol in owned and shelter dogs have found elevated levels for those living in shelter conditions (Sandri et al., 2015; Dudley et al., 2015) while dogs kenneled for first time experience three-fold increases in cortisol when entering the shelter compared to at-home levels (Rooney et al., 2007). The longer period of reflection offered by cortisol-to-creatinine ratios (C/C) in urine (3 +/- 1 hours; Schatz & Palme, 2001) makes these a reliable indicator of stress in shelter dogs. However, cortisol alone does not fully characterize the stress response system in dogs. Inclusion of urine-fractionated metanephrine and normetanephrine, metabolites of epinephrine and norepinephrine, indicates biological activity across the stress response system (Beerda et al., 2000).

Behavioral and cognitive paradigms have demonstrated sensitivity to differences in welfare when assessing dogs in animal shelters and those living in homes. Owczarczak-Garstecka and Burman (2016) observed that kenneled dogs that spent more time resting at a rescue center demonstrated a greater positive cognitive bias when tested in a spatial judgment task. Blackwell, Bodnariu, Tyson, Bradshaw, and Casey (2010) reported that dogs with higher C/C ratios tended to perform better in the learning of a shaping procedure which involved touching their nose to a bucket for food reinforcement. Barrera, Fagnani, Carball, Giamal, and Bentosela (2015) found that, in comparison to owned dogs, shelter dogs more quickly ceased their attempts to manipulate a food-dispensing toy when food was no longer present; and Protopopova, Hall, and Wynne (2014) found that, compared to typically behaving owned dogs, dogs with known stereotypic behaviors perseverated longer in a resistance-to-extinction task when a previously reinforced behavior was no longer rewarded.

A variety of behaviors have been suggested to be indicative of stress in kenneled dogs, including paw-lifting (Beerda et al., 1997; Beerda et al., 1999; Beerda et al., 2000; Hiby et al., 2006; Rooney et al., 2007), vocalizing (Hetts et al., 1992; Beerda et al., 1999), self-grooming (Beerda et al., 1999; Hetts et al., 1992), lip-licking (Hekman et al., 2012; Shiverdecker et al., 2013), and panting (Beerda et al., 1997; Hiby et al., 2006; Rooney et al., 2007; Shiverdecker et al., 2013; Hekman et al., 2014). While many of these studies measured the relationship between cortisol and behavioral welfare, few (with the exception of Beerda et al., 1999; 2000, as well as Part et al., 2014) have incorporated the use of other physiological measures involved in the stress response system.

The aim of this study was to characterize the relationship between the behaviors that dogs emitted freely in the kennels and their cortisol, metanephrine, and normetanephrine values as well as their heart rate, longest resting bout, and performance on a cognitive learning task using partial least squares path modeling to analyze these multiple relationships. By identifying in-kennel behaviors that are most strongly connected to these underlying physiological, health, and cognitive states, shelters will be able to use these indicators to more easily recognize dogs in compromised welfare states and intervene accordingly.

Methods

Animals

Sixty-two dogs housed at Arizona Humane Society (AHS; Phoenix, AZ) Sunnyslope campus were enrolled in the study from October to December 2017. The shelter is an open-admission facility that admits owner-surrendered, stray, and confiscated dogs into their care and had an intake in 2017 of 6,607 dogs. Dogs housed in one ward of the shelter, adjacent to the adoption kennels, were the participants in our study. This double-rowed ward of kennels was not accessible to the public, and dogs in these kennels were not available for adoption. Dogs that were extremely fearful or aggressive (thereby preventing collection of urine or handling during cognitive testing), or demonstrated signs of sickness were excluded from the study.

The majority of dogs (87%) were singly housed. Four pairs of dogs that were previously acquainted prior to shelter admittance were housed together. During video recording, a guillotine door that divided the indoor and outdoor areas was closed; thus for the purposes of this study, only the indoor area is relevant. The 1.15m (width) x 1.51m (depth) x 1.94m (height) kennels had coated cement floors with an elevated (by 0.09m) area for placement of a bed, side walls of cinder block and chain-link, back walls of cinder block, and chain-link doors. All kennels contained self-filling water bowls at the back of the kennel; and often had plastic beds and soft bedding (e.g., blanket or towel).

Information about the dogs (e.g., age, sex, mode of intake) was obtained via the shelter's database (Chameleon/CMS Software, HLP Inc., Huntington Beach, CA). Dogs had a minimum length of stay (LOS) of two days at the time of study participation.

Video recording

On each morning of data collection, shelter staff provided dogs the opportunity to urinate by taking them on leashed walks to an outdoor enclosure between 6:30-7:00 am. Over 80% of dogs received these walks and relieved themselves. Upon return to the kennels, staff closed the guillotine door, so that the dogs would remain in-view of the camera for video recording.

Security cameras (Zmodo, Shenzhen, China), were affixed atop a 1.28m-high cinder block wall 1.57 meters from the front of kennel, and recorded dogs' in-kennel behavior from 7:00-11:00 am. Recordings were directly saved to the security system's digital video recorder and downloaded for behavioral coding. Sixty-one dogs in the study had recorded videos for analysis, although two dogs were missing portions (less than half) of their four-hour recorded period due to equipment malfunction.

Health-Monitoring Collars

While video dogs were being video-recorded in their kennels, health-monitoring collars (PetPace, Shefayim, Israel) collected dogs' relative (to their normal) temperature, pulse, respiration, activity, and positions through the use of acoustics, 3-D accelerometer, and thermistors for the same time period. Collar data was transmitted via ultra high frequency radio to nearby internet-connected base units, which sent information to PetPace online data portals for analysis. For the purposes of this study, average pulse rate and longest bout of uninterrupted rest were calculated for each dog and used in the statistical analysis.

Urine Collection

After video recording was completed at 11:00am, dogs were leashed and removed from their kennels for an on-leash walk to an outdoor location for elimination. Samples were collected using Olympic Clean-Catch™ plastic trays taped to 36-inch (91-cm) "Pickup and Reach" tools (Harbor Freight, Calabasas, CA). After collection, samples were poured into 10 mL plastic conical bottom centrifuge tubes with screw caps for storage. Collection trays were rinsed with water after use.

Urine samples were collected between 11:01 am and 12:00 pm and immediately placed in a cooler with ice. Less than 10% of samples fell outside this collection range due to dogs not urinating when walked or not providing an adequate volume of urine (1.5 mL). In these cases, dogs were provided a mixture of wet food and water before another attempt at urine collection was made. Time of collection was noted for each sample and, after collection, dogs were returned to their kennels.

Frozen urine samples were shipped overnight on dry ice to Animal Reference Pathology (Salt Lake City, UT, USA) with analysis occurring within one month of sample collection. Cortisol was measured using a commercially available product designed for an enzyme-amplified chemiluminescence assay system (Immulite 1000, Diagnostic Products Corporation, Los Angeles, CA, USA) with creatinine measured using an automated wet biochemistry analyzer (Dimension Xpand Plus, Siemens Healthcare Diagnostics, Newark, DE, USA). Cortisol: creatinine ratios (measured in μmol/l: μmol/l) $\times 10^{-6}$ were then calculated.

Catecholamines were analyzed at Associated Regional and University Pathologists (Salt Lake City, UT, USA) using high-performance liquid chromatography (API 3200 LC/MS/MS, Applied Biosystems, Foster City, CA, USA) with creatinine measured using an automated wet biochemistry analyzer (Architect ci8200, Abbott Core Laboratory, Lake Forest, IL, USA). Metanephrine: creatinine and normetanephrine: creatinine ratios (measured in μg:g) were then calculated.

Cognitive Testing

After the completion of urine collection, dogs were leashed, removed from their kennels, and brought to a testing area at AHS (6.55m wide x 6.58m long) to complete a cognitive flexibility task. In this task, two identical, small boxes (0.20m wide x 0.11m deep x 0.30m tall) fitted with lidded, weighted bowls (0.13m diameter x 0.06m tall) and food odor controls (hot dogs), were presented as response choice objects for the dogs. Boxes and associated bowls were placed 1m apart from each other in the center of the room, 3.00m from the dog (with boxes on their short sides and with their open sides facing away from the dog), and 1.75m from the experimenter.

Upon entering the room, dogs were given a three-minute off-leash acclimation period to familiarize themselves with the room and its contents, testing apparatuses, experimenter, and research assistant. After three minutes, training of the experimental procedure began, consisting of two phases. Dogs first received three sets of randomized left- and right-side reinforced trials in which a small piece of hot dog (approximately 6 mm x 6 mm x 3 mm) was placed atop one of the lidded, weighted bowls. Thereafter another three sets of trials commenced in which the food was placed atop one of the lidded, weighted bowls, which were now inside the boxes, in an effort to shape the dog's ability to perform the task during testing. Hereafter reference to boxes implies that the boxes have the bowls inside them. Only one bowl or box was presented to the dog at a time in these training trials; twelve training trials were provided in all.

Throughout training and testing, the research assistant placed dogs in an adjoining room while the experimenter baited the boxes. Then the assistant brought the dogs to the starting position (3m from the boxes). At this time, the experimenter stepped forward so as to be equidistant from both objects, sounded a bell, stepped back 1m (subsequently affixing her gaze at a point on the opposite wall) and then the research assistant released the dog. Only one box was presented during these training trials, thus no incorrect choices were possible, except if no choice was made after two minutes had elapsed. This was the maximum trial time in both training and testing. Once a dog had made its choice and consumed the food, it was guided back to the research assistant for the next trial.

Training was completed to a criterion of fewer than three no-choice trials with dogs that made three or more no choices being excused from further testing. Each dog received thirty experimental trials with both boxes. On each trial one box (unknown to the dog) was baited. Trials were scored as correct if the dog chose the baited box and incorrect if the un-baited box was chosen. Once the dog indicated a choice and had consumed the food in the box if the correct choice had been made, the experimenter guided the dog back to the research assistant, thus allowing interaction with only the first chosen box. After three successive correct trials the previously un-baited box became the baited box, and the previously baited box was not baited.

Baiting of any one box continued until three successive choices of that box were made; three, successive trials with no choice within two minutes concluded testing. All completed experimental trials were scored as correct or incorrect, and choice latency for each trial was recorded. We calculated the proportion correct (number of correct experimental trials / completed experimental trials) and number of blocks completed (three, successive correct trials resulting in a baiting reversal) for statistical analysis.

Behavioral Coding

Following the recording of the dogs' in-kennel behavior, videos were coded using the Behavioral Observation Research Interactive Software (BORIS: Friard, 2017). All coded behaviors are listed in the ethogram included in Table 7-1. This ethogram was developed based on previous peer-reviewed publications, primarily Protopopova et al. (2014) as well as behaviors published in Hiby et al. (2006), Part et al. (2014), McCullough et al. (2018), Walker et al. (2014), Bower and Smuts (2007), and Overall (2014). Due to sound limitations of the video recording technology, growling and whining were excluded from coding.

All coders were trained to 90% agreement on practice videos prior to data coding. Videos were analyzed using a continuous coding procedure with sampling of one-minute durations every three minutes, resulting in 80-minutes of behavioral data for the 61 dogs for which video recordings were available. For two dogs that were missing portions of video, a more frequent, but evenly distributed, sampling procedure was used instead. To standardize durations of observed behaviors to account for time in which dogs were out of sight from video recording (when guillotine doors were open), behaviors were converted to proportions of time observed. Three dogs whose duration of time out of sight was greater than 1,200s (one-quarter of total time coded) were removed from the statistical analysis.

Statistical Analysis

A variable quality selection procedure was implemented to reduce the likelihood of spurious associations with rarely seen behaviors. All variables for which fewer than 16 dogs (25% of sample) displayed the behavior were removed. These behaviors were begging, belly up, cowering, eliminating, interacting with a person, leaning on the door, lunging, play bowing, regurgitating, and tucked tail. Upon considering the small sub-sample size of pair-housed dogs (8), behaviors emitted upon the subject dog by the kennelmate or emitted by the subject dog upon the kennelmate were not included in the analysis. In total, 29 behaviors were considered and normalized by z-score computation prior to our exploratory analysis.

To identify which variables would be tested for goodness of fit in the path analysis, multiple linear regression analyses with backward elimination were conducted to determine whether any of the behavioral, heart rate, or resting bout variables could be predicted from dogs' cortisol, metanephrine, or normetanephrine:creatinine ratios. For inclusion of cognitive testing performance in the path analysis, multiple linear regression analyses with backward elimination were employed to assess whether dogs' proportion correct or number of blocks completed on the task could be predicted from any of previously identified behavioral variables.

To determine whether the physiological influenced behavior and health variables, we conducted a path analysis using the *plspm* package in R (Sanchez, 2013). Observed in-kennel behaviors were categorized into behavioral groups based on physiological relationships identified in the multiple linear regression analyses. In the model, these groups are known as latent variables, which are underlying constructs used in path analysis that help explain the association between each grouping of observed behaviors. In the path analysis, each physiological measure was entered as a formative or causal indicator while heart rate and behaviors were reflective indicators of their effect. Initial and subsequent partial least squares path models were fit, and the loadings, cross loadings, Cronbach's alpha, and Dillon-Goldstein's rho were evaluated for unidimensionality (the relatedness of the behavior groups). Behavioral indicator variables that were poorly correlated with their grouping (Cronbach's alpha and Dillon-Goldstein's Rho < .7) were placed into better-fitting latent variables or removed from the analysis.

To evaluate whether the latent physiological variables were associated with health and behavior, we describe a structural model in which Cortisol, Metanephrine, and Normetanephrine predict Heart Rate and Behavior Groups.

Results

Sixty-two dogs at AHS participated in the study. These dogs arrived at the shelter most often surrendered by their owners (58%) and had been housed for an average of 9.37 days (*SD* 9.70; range: 2-53) at the time of participation. Dogs weighed a mean of 24.55kg (*SD* 7.53: range 3.63-42.05) and were usually male (53%). Descriptive statistics are included in Table 7-2.

Sixty-one dogs returned measurable cortisol:creatinine (C/C) values with an average of 29.09 x 10^{-6} (*SD* 13.57) with a range of 7.40-66.35 reported. Cortisol values from two dogs that were greater than three standard deviations above the mean were removed from analysis: Dog 3: 334.22 x 10^{-6} and Dog 48: 100.45 x 10^{-6}. The mean metanephrine:creatinine (M/C) ratio was 85.02 (*SD* 37.98) with a range of 24.00-193.00. Dog 48, whose M/C value was 326.00, was not included. The average normetanephrine:creatinine (NM/C) ratio value was 171.25 (*SD* 62.00) with a range of 82.00-333.00. Two NM/C values, Dog 3: 500.00 and Dog 25: 462.00, were removed from further analysis. Thus, 59 cortisol:creatinine, 61 metanephrine:creatinine, and 60 normetanephrine:creatinine values were used in our analysis.

During the four-hour observational period, pulse rates were detected on 52 dogs via the health-monitoring collars with an average rate of 70.75 bpm (*SD* 9.22) and a range of 55.00-97.67. The average bout of longest rest during recording was 11.84 min (*SD* 5.17) with a range of 2.00-24.00. Of the 58 participant dogs in the cognitive flexibility task, 49 completed training and were tested in the experimental phase. Excluding those dogs that participated in the experimental phase but did not make a single correct choice (3), the mean proportion correct was 46.79% (*SD* 14.80) with a range 10.00-66.67. Dogs completed an average of 1.91 blocks during testing (three successive choices indicating a reversal in baiting) with a range of 0-6 blocks. Means and standard deviations for physiological, heart rate, sleep, and cognitive performance variables are included in Table 7-2.

Table 7-3 displays descriptive statistics for 29 behaviors entered into the multiple regression analyses, including the number of dogs that displayed the behavior, the average proportion of time spent in each behavior along with the behavior's standard deviation and range. On average, dogs displayed no behavior for more than half of the coded eighty minutes. Dogs most often were observed lying down with their heads down (42.70%, *SD* 63.64) followed by standing (19.57%, *SD* 15.95), lying down with their heads up (19.56%, *SD* 12.51), and sitting (15.39%, *SD* 12.42). All other behaviors were displayed less than 10% of the time or were coded as count behaviors, such as barking, yawning, and lip licking.

Prior to conducting the path analysis, multiple linear regression analyses with backward elimination were used to explore whether any behavior, pulse, or rest variables significantly predicted C/C, M/C or NM/C ratios. Those variables would then be considered in the path analysis. Table 7-4 includes those variables and their corresponding beta coefficients, standard errors, *t*-test and *p*-values when tested. Fifteen variables showed statistically significant relationships ($p \leq .05$) to either C/C, M/C, or NM/C, including barking, drinking, licking on kennel, licking self, lip licking, lying down with head down, panting, pawing at kennel, sitting, standing, stretching, wagging tail, yawning, and average pulse rate. In consideration of the exploratory nature of the study design and analysis, four behaviors demonstrated statistical significance at $p < 0.20$ in predicting cortisol, metanephrine, or normetanephrine values are included here: howling, manipulating object, pawing at door, and longest bout of uninterrupted rest.

When analyzing the relatedness of our cognitive measures to our behavioral variables, two behaviors demonstrated significant relationships: a positive correlation was observed with standing and proportion correct while a negative correlation was detected with licking self and completed blocks. Thus, as dogs stood more while in their kennels, the number of correct trials during cognitive testing increased. Conversely as dogs licked themselves less, the number of blocks they completed on the cognitive flexibility task increased. Table 7-5 includes the results of those analyses. Since both cognitive performance variables related only to single behaviors, proportion correct and completed blocks were not included in the path analysis.

To evaluate whether cortisol, metanephrine, and normetanephrine were related to pulse rate and behavior, we employed a partial least squares path model. In order to explore all likely relationships in the path analysis, behaviors with a significance value of

$p < 0.2$ in the multiple regression analyses were considered (though not necessarily retained) during path model construction. Established exclusion criterion for relatedness of a single behavior to its group, Cronbach's alpha and Dillon-Goldstein's Rho ≤ 0.7, and model goodness-of-fit were used. Four behavioral latent variables were retained in the final model (Figure 7-3). Behavior Group 1 (BG1): lip licking, licking kennel, drinking, pawing door, and standing; Behavior Group 2 (BG2): barking, panting, pawing kennel, wagging tail, licking door; Behavior Group 3 (BG3): yawning, and Behavior Group 4 (BG4): scratching, lying down with head down, licking self, and stretching; Figure 7-4 shows the hypothesized path model with coefficient estimates.

Table 7-6 shows the model estimates with path coefficients, standard errors, *t*-test statistics, and *p*-values. Overall, dogs' pulse rates and behaviors were related to our physiological measures, varying in the number of relationships and their strength. As expected from our multiple regression analyses, as metanephrine decreased (estimate = -.36, $p = .015$), dogs' pulse rates increased; and increases in normetanephrine (estimate = .61, $p < .001$) were associated with higher pulse rates. BG1 and BG2 demonstrated the strongest associations to and engagement of the stress response system. As C/C and M/C increased (estimate = .33, $p = .009$; estimate = .54, $p < .001$ respectively), BG1 activity increased. Conversely as NM/C decreased (estimate = -.45, $p = .002$), BG1 increased. Increases in M/C (estimate = .44, $p = .005$) and a trend with C/C (estimate = .22, $p = .103$) were associated with increased BG2.

Both BG4 and BG3 demonstrated overall disengagement of the stress response system although the relationships were not as pronounced as for BG1 and BG2. As both

M/C (estimate = -.57, $p < .001$) and C/C (estimate = -.24, $p = .058$) decreased, BG4 increased. NM/C increases were associated with increased BG3 activity (estimate = .27, $p = .068$). With BG3, both C/C and NM/C (estimate = -.24, $p = .081$; estimate = -27, $p = .099$) demonstrated trends, such that as these physiological measures decreased, BG4 increased.

Discussion

Our aim here was to characterize the relationships between multiple physiological measures and behavior. We were able to identify four groups of behaviors from in-kennel observations that showed significant relationships to our stress response indicators: cortisol, metanephrine, and normetanephrine. Additionally, in our model we were able to demonstrate relationships between heart rate and metanephrine and normetanephrine, indicating its involvement in the stress response system. Two in-kennel behaviors that were associated with greater stress responding, standing and licking self, predicted performance in our cognitive flexibility task, demonstrating its ability to measure welfare in this environment.

Previous studies on the welfare of kenneled dogs have investigated the relationships between urinary cortisol and behavior, yet few publications have incorporated the use of urinary catecholamines to contextualize these dogs' stress response in the emission (and duration) of individual behaviors (Beerda et al., 2000; Part et al., 2014). Part et al. (2014) explored differences between home and kenneled conditions and found higher levels of C/C and vanillylmandelic acid:creatinine ratios (VMA/C) a metabolite of epinephrine and norepinephrine), in dogs living in a boarding facility, thus characterizing its stressfulness. While Part et al., (2014) reported that dogs in the kennel showed behaviors such as lying down and resting less often, and alertness, sitting, standing, ambulating, and panting more frequently, only lip-licking in the kennel environment was directly predictive (negatively) of VMA ratios.

In our study, we found lip-licking to be positively associated with both cortisol and metanephrine and negatively with normetanephrine in both the multiple regression and path analyses, such that increased lip-licking predicted higher cortisol and metanephrine values and lower normetanephrine. Hekman et al. (2012) also found this same relationship with lip-licking and salivary cortisol levels in hospitalized dogs. In our path analysis, lip-licking demonstrated similar physiological responding with behaviors such as licking the kennel, drinking, pawing and standing.

When dogs were exposed to different environmental conditions in Beerda et al. (2000), significant relationships were found between the austerity of the housing conditions and cortisol, adrenaline, and noradrenaline values, as well as between austerity and behavior. The direct relationship to physiology and behavior was less clear however. Walking, circling, and urinating were found to correlate with C/C ratios but no relationships were found with adrenaline or noradrenaline. In our study, we found circling did not occur and eliminating occurred so infrequently during the four hours of observation that it was not included in our analysis. However, walking as well as any of the locomotor behaviors that were coded, including jumping on the door and jumping on the kennel, were not predictive of physiological values.

We were able to confirm through our use of multiple physiological and cognitive measures that many behaviors found in prior studies, either observationally or through the use of a single physiological measure, cortisol, were likely indicators of stress and welfare in kenneled dogs. Hetts et al. (1992) and Beerda et al. (1999) both identified vocalizing as a behavior correlated with social isolation. Beerda et al. (1996), Hiby et al., (2006), Rooney et al. (2007), and Hekman et al. (2014) had previously identified increased panting as a behavior associated with greater stress responding. In our analysis we found that dogs that barked and panted more, along with increased kennel pawing, tail wagging, and door licking (including chewing and biting), had significantly higher metanephrine and trending higher cortisol values.

Curiously, self-grooming has been reported to be associated with poorer welfare when dogs experience environmental manipulations perceived as more stressful (Beerda et al., 1999; Hetts et al., 1992); however, in our study we found that when dogs demonstrated greater self-licking, scratching, stretching, and lying down with the head down, they had reduced stress responding across all parameters. With regards to the indicative value of lying down with head down, Hekman et al.'s (2014) also found that dogs resting more with their heads on their paws or kennel showed reduced salivary cortisol.

Our cognitive measure that tested dogs' flexibility in adapting to changing contingencies, blocks completed, was also related to dogs licking themselves, such that less licking was predictive of better performance on the task; and the proportion of correctly performed trials correlated with standing, such that more standing was correlated with better performance. Briefly, a dog with a greater number of blocks completed during testing would indicate that he/she recognized a previously baited box was no longer reinforced and demonstrated flexibility or sensitivity to changing contingencies in approaching the previously unbaited box. Dogs with decreased sensitivity or that perseverated in their responding to a particular box that was previously reinforced would likely complete fewer blocks. While we did not find a relationship with block completion or proportion correct to any individual physiological measure (and were unable to include it in our path analysis because of its relationship to individual behaviors, not behavioral groupings), their relationships to two behaviors in a behavioral grouping associated with greater stress responding is convergent with research on cognitive or behavioral flexibility (Snyder, Wang, Han, McFadden, & Valentino, 2012; Graybeal et al., 2011; Bryce & Howland, 2015). In these studies, engagement of the stress response system was found to have an enhancing effect (albeit dependent on stressor intensity), allowing individuals to selectively and adaptively respond to their changing environment, which would support our findings here.

Despite its prevalence in the literature (Beerda et al., 1997; Beerda et al., 1999; Beerda et al., 2000; Hiby et al., 2006; Rooney et al., 2007) we did not identify any predictive value of paw-lifting to our physiological or cognitive measures. Considering that we observed the behavior in nearly half of the dogs in the study this lack of correlation is unlikely to be due to a shortage of observations of this behavior. We did find that yawning was indicative of a trending reduction in stress response (with decreased cortisol and normetanephrine), but it has a unique relationship to our physiological measures, and was not correlated to our low-stress Behavior Grouping 3, thus requiring its own latent variable. Previous research has offered a conflicted role of yawning, describing it as a displacement behavior (Hennessy et al., 1998; Hennessy et al., 2006) as well as indicative of acute stress (Beerda et al., 1998; 2000). Our results here suggest that while yawning's association with lower cortisol is indicative of reduced stress responding, its directionally engaged relationship to metanephrine release (as opposed to Behavior Group 3's significant disengagement of M/C) supports an interpretation that yawning is more environmentally sensitive than behaviors such as scratching, lying down with head down, licking self, and stretching, but still indicative of lower stress.

We were surprised by the opposing directions of action in metanephrine and normetanephrine observed throughout our results, considering their coordinated release from the adrenal medulla and sympathetic nervous system (Chen et al., 2015; Del Giudice et al., 2011). Upon further examination, however, we find that the action of these hormones is divergent based upon differential affinities for adrenergic receptors as well as differences in production quantities and release throughout the body (Furchgott, 1959). Goldstein and Kopin (2007) report that across a range of stressors in different species, epinephrine release correlates more strongly with cortisol responding than norepinephrine.

The limited predictive value of the longest bout of rest to metanephrine and its lack of fit in the path analysis model was unexpected, considering its relationship to reduced cortisol and positive changes in rest between shelter and foster settings (Gunter, Feuerbacher, Gilchrist, Beckstrom-Sternberg, and Wynne, in prep). One likely explanation is that the shorter observational period of four hours in-kennel versus six days during our temporary fostering study played a role. Conclusions drawn from Owczarczak-Garstecka & Burman (2016) with regards to the impact of sleep on measures of cognitive bias and repetitive behaviors resulted from behavioral observations gathered over 24-hours-a-day for five non-consecutive days.

To our knowledge, this is the first report to relate co-occurring physiological measures of stress response to the behavior of shelter dogs using a path analysis approach. Based on the groupings of our observable behaviors, we see the development of a behavioral spectrum that describes the welfare of shelter-living dogs as multiple systems of stress responding are engaged.

From our analysis, we can infer that Group 4 behaviors: scratching, lying down with head down, licking self, and stretching are associated with the lowest responding of our physiological parameters, such that observing these behaviors more often in the shelter would indicate that a dog was coping relatively well in this environment. Group 3, likely less so but still demonstrating reduced responding. Conversely, dogs observed displaying behaviors in Groups 1 and 2 may be experiencing reduced welfare. An evidence-based tool such as this could provide shelters, who may have varying degrees of behavioral expertise, the ability to use these indicators as a guide in identifying dogs that are in compromised welfare states and direct interventions to individuals that are most in need.

One limitation in our study is that it is possible that the four hours of in-kennel observations that resulted in 80 minutes of coded behavior for each of the 61 dogs in the study was insufficient to capture the range of possible behaviors (and relationships to physiological measures) emitted by shelter dogs. Protopopova et al. (2014) recorded nearly 300 dogs and coded over 40 behavioral variables to describe the in-kennel behavior of dogs in a shelter in Florida. Nevertheless when examining the behaviors significantly associated with increased length of stay in that study (removing behaviors that were related to the presence of an observer which our study did not have), we find that walking, leaning on the kennel wall, and standing were also significant predictors in our models.

Additionally while our findings describe the welfare of dogs at one open-admission shelter in Phoenix, Arizona, it is likely studies observing the behavior of shelter dogs living elsewhere under different environmental conditions will come to different conclusions; thus replication and the incorporation of additional measures of stress responding, such as such as susceptibility to disease, are needed to further improve our understanding. One such candidate measure is secretory Immunoglobulin-A (s-IgA), which is present throughout the body's mucous secretions, such as saliva, and is one of the body's primary responses to bacterial infection and viral defense (O'Leary, 1990). S-IGA has previously been used to detect differences in welfare in pair-housed shelter dogs (Walker et al., 2014) as well as service adaptability in guide and police dogs (Kikkawa, Uchida, Suwa, & Taguchi, 2005; Takahasi et al., 2009).

Conclusion

This exploratory study demonstrates the ability through the use of multiple physiological measures to detect the internal stress responding of shelter-living dogs manifested in their overt, in-kennel behavior. Our findings suggest a behavioral spectrum of welfare likely exists for shelter dogs, in which behaviors such as panting, lip-licking, and standing are associated with reduced welfare and behaviors such as lying down with head down and stretching predict greater welfare. While replication is needed to further validate the reliability of these behavioral indicators, this study is a first step in the development of tools to assess and improve the welfare of dogs living in shelters.

SECTION 4

SHELTER DOG WELFARE

CHAPTER 8

GENERAL DISCUSSION

This dissertation describes a series of studies that answer questions relevant to the welfare of dogs living in animal shelters.

In Chapter 2, the breed identities of dogs living in two animal shelters were qualified and quantified through genetic breed testing. The accuracy of visual breed identification was also compared to genetically derived breed assignment. In this study, shelter dogs showed a much greater range of breed diversity and complexity of breed heritage than is widely assumed by shelter personnel, and only a very small percentage of purebred dogs was identified in the sample. The ability of staff to correctly identify the heritage of mixed breed dogs in the shelters was low; consequently, the breed assignments made by staff were often inaccurate.

Chapter 4 examined the efficacy of a post-adoption intervention intended to reduce returns of adopted dogs to the shelter by encouraging physical activity between new owners and their dogs. In this study, adopter-dogs pairs in the intervention group were not significantly more active than those in the control group, nor did they show a reduced incidence of returning their dogs. Owners in both groups who reported higher obligation and self-efficacy in their dog walking were more active regardless of experimental condition. While owners who reported higher obligation and self-efficacy in their dog walking were more active with their dogs, obligation, dog walking self-efficacy, and perceptions about their dogs' on-leash behavior did not predict rates of return to the shelter.

In Chapter 6, the impacts of a temporary fostering intervention on the stress of shelter-living dogs were assessed. Conducted in five shelters across the country that varied in admission type and annual intake, this study demonstrated that shelter dogs' urinary cortisol concentrations decrease systematically when the dogs are placed into a fosterer's home for one and two nights. While a reprieve from the shelter was impactful on the dogs' welfare (although the magnitude of effect varied), we also identified that cortisol levels differed significantly between shelters, suggesting that stressors in these environments may be important contributing factors to a dog's welfare.

Chapter 7 reported a path analysis model which incorporated multiple measures of stress responding to predict observations of in-kennel behavior, providing evidence of a behavioral spectrum of welfare for shelter-living dogs. At one extreme of stress response engagement, dogs would more often be engaged in behaviors such as lip licking, licking the kennel, drinking, pawing the door and standing in the kennel as well as barking, panting, pawing the kennel, tail wagging, and licking the door. At the opposite extreme of stress response disengagement, dogs would more often be observed scratching themselves, lying down with head down, licking themselves, and stretching as well as yawning. These findings support as well as contradict several long-standing, but unscientific, assumptions about behaviors that indicate stress or relaxation in dogs.

Describing Dogs in Animal Shelters

Considering the complexity of shelter dog breed heritage coupled with the failure to correctly identify multiple breeds based on visual identification, it would likely best serve shelters to instead focus their resources on communicating the physical and behavioral characteristics of individual shelter dogs. Despite the insights provided by genetic testing in identifying the individual breeds in the heritage of a mixed breed dog, there is currently little understanding about how multiple breeds interact to influence the behavior of each individual mixed-breed dog. Thus, a more viable alternative in animal sheltering is to remove breed labels from the descriptions of dogs displayed on websites and kennel cards. This low-cost intervention has previously been shown to improve adoptions and reduce lengths of stay for dogs at one animal shelter, with a particularly beneficial impact on pit bull-type dogs, but with benefits to all dogs (Gunter et al., 2016).

Without breed designations on kennel cards and the stereotypes that often accompany those labels, shelters have the opportunity to more accurately describe the physical and behavioral traits of the dogs in their care. One way in which shelters can communicate the behavior of the dogs in their care would be through the use of a fully validated behavioral assessment (Taylor & Mills, 2006). While some form of behavioral assessment are utilized in many shelters (Mornement, Coleman, Toukhsati, & Bennett, 2010; King, Marston, & Bennett, 2012), few, if any, of these behavioral assessments meet accepted criteria for standardization, validity and reliability for psychological testing (Haverbeke, Pluijmakers, & Diederich, 2015; Rayment, De Groef, Peters, & Marston, 2015).

Nonetheless, focusing research efforts on assessments that address these concerns would be beneficial to potential adopters and shelter dogs (Overall, 2015). Follow-up studies comparing adopter satisfaction pre- and post-label removal at shelters would likely be useful in determining whether the absence of such breed information is detrimental to the adoption experience, as well as whether any other information becomes more impactful in the decision-making process.

Helping Owners, Helping Dogs

Although previous research has identified owner risk factors associated with the surrender of owned dogs and failed adoption of shelter dogs, there are no validated interventions that have systematically altered the number of dogs arriving at shelters.

An added complication in this domain is that it is logistically difficult to accurately study returns at individual study sites as not all owners return dogs to the shelter from which they were acquired. Furthermore, return rates may not be the best measure of adoption success as adopters may not maintain ownership of their dog but utilize options other than shelter relinquishment. Weiss et al. (2014) found that roughly three-quarters of relinquishing owners in two large US cities attempted to rehome their dogs with friends or family before arriving at the shelter. New technologies, such as smartphone applications and GPS tracking devices, may soon provide ways to track the location of dogs without having to rely exclusively on owner reporting. The movement of feral cats, for example, has already been investigated with these technologies (Recio, Mathieu, Maloney, & Seddon, 2010).

As discussed in Chapter 2, there is likely a temporal component to failed adoptions, considering that nearly one-half of returned dogs arrive back at the animal shelter within the first month of adoption. What is less understood is the interaction between length of ownership and the type of return. Understanding what motivates owners later in the relationship to surrender their dog could be helpful in determining what kind of information is provided to adopters throughout the dog's life. Considering that a majority of new owners reported in Shore (2005) observed that the behavior problem that led to their returning the dog to a shelter soon after adoption and the top reasons for adopter return included pet and child incompatibility, we may find that certain temperament issues of the dog drive immediate returns, whereas relinquishments that occur later in the owner-dog relationship are driven by issues unrelated to the dog. If this is indeed the case, interventions designed to increase ownership success could begin even before the adoption takes place by encouraging introductions for families that have children and/or other pets to avoid preventable conflicts with resident household members. Once the dog is successfully living in the home, services that support the owner may play a bigger role in continued adoption success.

Leaving the Shelter: A Welfare Intervention

While prior studies provide convincing evidence that the stress levels of dogs living in shelters are higher than those of owned dogs (Sandri et al., 2015; Dudley et al., 2015), what is less understood is the stress dogs experience when transitioning from shelter-living to home and then return to the shelter. Hiby et al. (2006) identified that the cortisol levels of owner-surrendered dogs increased over the first ten days in the shelter, suggesting that entering a shelter from a home could be stressful. Uncertainty about this particular impact of the fostering intervention concerned shelters that participated in the study described in Chapter 6.

However when we examine the cortisol levels of dogs after return from their sleepovers, the data suggests otherwise (Table 6-4). Of the four shelters whose dogs experienced two-day fostering and subsequently two days of post-sleepover cortisol measurement, dogs at three of the four shelters had lower values on the second day as compared to the first post-sleepover day in the shelter. While these reductions were not statistically significant, nevertheless they do provide support that returning to shelter after a brief absence is not increasingly stressful for shelter dogs.

As discussed in Chapter 5 and Chapter 7, it is unlikely that the single physiological measure of urinary cortisol fully describes the stress responding of dogs that participated in the temporary fostering intervention. Insights from the health-monitoring collars suggest that not only were dogs' cortisol levels negatively associated with their longest bout of rest, but dogs experienced their longest bouts of rest in the foster home, with the second-longest rest bout post-sleepover in the shelter. This supports anecdotal reports from shelter staff that dogs appeared more relaxed in their kennels after fostering and posits that such interventions could improve or maintain the behavioral health of dogs awaiting adoption. Thus if we consider that cortisol levels decreased for dogs during their sleepovers, that cortisol levels were not significantly higher post-sleepover and that there may be a behavioral benefit to sleepovers on dogs' in-kennel behavior, it is possible that leaving the shelter as part of a temporary or trial adoption, as described in Normando et al. (2006), may improve the welfare of shelter-living dogs as well as increase their likelihood of adoption.

Improving the Lives of Shelter Dogs

Through the use of multiple physiological measures in the study described in Chapter 7, we were able to identify in-kennel behaviors that are related to the internal stress responding of shelter dogs. Correlating physiological parameters to behavior is not novel in the domain of shelter dog welfare; three behaviors suggested by Hekman et al. (2012) that correlated to salivary cortisol levels of hospitalized dog – head resting, panting, and lip licking – were also shown in our model to be indicative of lower and higher stress responding, respectively. Shiverdecker et al. (2013) also previously identified panting and lip licking as candidate stress behaviors.

What this study's model adds to our understanding of shelter dog welfare is the recognition that there are no singular bell-weather behaviors, such as the presence or absence of stereotypic behaviors, that shelter personnel should be monitoring. Instead, the model proposed here indicates that dogs display a spectrum of indicator behaviors that provide insights into their welfare state. In the regression analyses conducted prior to the path analysis (Table 7-4), behaviors that correlated to multiple physiological measures were also those that had been identified in prior publications, such as lip licking, lying down with head down, panting, and standing (Chapter 5). However in the crossloadings within each latent variables, we find that lip licking and standing are more closely related to each other than panting. This is likely because both lip licking and standing are associated with increased cortisol and metanephrine responding. Panting, also a behavior predictive of increased stress responding, is related to behaviors like tail wagging and barking with all three physiological responses engaged. Additionally, lying down is not the only behavior indicative of disengaged stress responding; another behavior, stretching, has similar responding but is more strongly predicted by cortisol and normetanephrine.

When we examined the engagement of the individual systems of stress responding, no single physiological parameter – cortisol, metanephrine or normetanephrine – described the entirety of the animal's experience as it copes with its environment (Table 7-6). For example, the predictive ability of cortisol for the behaviors in both Groups 2 (barking, panting, pawing at the kennel, wagging tail, and licking the door) and 3 (yawning) is trending but neither relationship is significant nor was cortisol related to pulse rate. Yet, cortisol is strongly predicted behaviors in Groups 1 (lip licking, licking the kennel, drinking, pawing the door, and standing) and 4 (scratching, lying down with head down, licking self, and stretching). Additionally, metanephrine predicted all groups of behaviors except for yawning. Perhaps one way we can characterize the stress responding of dogs in this study is to view the level of hormonal engagement as the difference in the dog's expectation of its surroundings and the actuality of what occurs (Ursin & Eriksen, 2004). With this perspective, we can imagine that multiple physiological measures are likely needed to characterize the entirety of the stress response.

The purpose of the study in Chapter 7 was to aid animal shelters in improving the lives of dogs in their care. Using the behaviors identified here as a guide, shelter personnel with minimal training could identify dogs in compromised welfare states and intervene appropriately. For shelters that are able to augment their daily care with enrichment interventions described in Chapter 5, these behaviors could provide a means to assess the efficacy of those interventions.

Conclusions

Throughout this dissertation, I attempted to further my understanding about the dogs residing in animal shelters in hopes of bettering their lives. I learned that the breed identities of shelter dogs were much more complex than previously believed, and labeling these dogs with just one or two breeds minimizes the diversity of breeds available o adopters in animal shelters. I found that providing a one-size-fits-all exercise intervention to new adopters in hopes of strengthening the new bond was naïve when we consider the nuances of the human-dog relationship. Much to my surprise, I found that having dogs simply leave the shelter for one or two nights could significantly reduce their stress levels while awaiting adoption. Further investigation is needed to understand the additional benefits to behavior and adoptions that temporary fostering may provide to shelter dogs. I learned that by using multiple physiological measures to characterize the stress responding of shelter dogs, it is possible to uncover the subtle relationships between behavior and welfare. It is my hope that this last study is just a first step in developing a behavioral tool that animal shelters could use to better the lives of dogs living in shelters.

References

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park: Sage.

Alberghina, D., Rizzo, M., Piccione, G., Giannetto, C., & Panzera, M. (2017). An exploratory study about the association between serum serotonin concentrations and canine-human social interactions in shelter dogs (Canis familiaris). *Journal of Veterinary Behavior: Clinical Applications and Research*, *18*, 96-101.

American Society for the Prevention of Cruelty to Animals. (2016). *Pet statistics*. Avaiable at: https://www.aspca.org/about-us/faq/pet-statistics. Accessed April 28, 2016.

American Society for the Prevention of Cruelty to Animals. (2018) *Pet statistics.* Available at: https://www.aspca.org/animal-homelessness/shelter-intake-and surrender/pet statistics. Accessed February 18, 2018.

American Kennel Club. (2014). *Breed identification guide*. New York City, NY: American Kennel Club.

American Kennel Club. (2016). *Breaking news: The Labrador Retriever wins top breed for the 26th year in a row.* Retrieved from: http://www.akc.org/content/news/articles/the-labrador-retriever-wins-top-breed-for-the-26th-year-in-a-row/.

American Pet Products Association. (2016). *Pet industry market size & ownership statistics.* Available at: http://www.americanpetproducts.org/ press_ industrytrends.asp. Accessed April 28, 2016.

Banfield Pet Hospital. (2016). *State of pet health report.* Retrieved from: https://www.banfield.com/Banfield/media/PDF/Downloads/soph/Banfield-State-of-Pet-Health-Report-2016.pdf. Accessed February 26, 2017.

Barnard, S., Chincarini, M., Di Tommaso, L., Di Giulio, F., Messori, S., & Ferri, N. (2015). Free-roaming dogs control activities in one Italian province (2000-2013): Is the implemented approach effective? *Macedonian Veterinary Review*, *38*(2), 149-158.

Barrera, G., Fagnani, J., Carballo, F., Giamal, Y., & Bentosela, M. (2015). Effects of learning on social and nonsocial behaviors during a problem-solving task in shelter and pet dogs. *Journal of Veterinary Behavior: Clinical Applications and Research*, *10*(4), 307-314.

Barrett, K., & Greene, R. (2015, October). *Do Animal Shelters Serve People or Pups?* Available at: http://www.governing.com/columns/smart-mgmt/gov-animal-control-management.html. Accessed Feb 12, 2017.

Bartlett, P. C., Bartlett, A., Walshaw, S., & Halstead, S. (2005). Rates of euthanasia and adoption for dogs and cats in Michigan animal shelters. *Journal of Applied Animal Welfare Science*, *8*(2), 97-104.

Beerda, B., Schilder, M. B., Bernadina, W., Van Hooff, J. A., De Vries, H. W., & Mol, J. A. (1999). Chronic stress in dogs subjected to social and spatial restriction. II. Hormonal and immunological responses. *Physiology & Behavior*, *66*(2), 243-254.

Beerda, B., Schilder, M. B., Janssen, N. S., & Mol, J. A. (1996). The use of saliva cortisol, urinary cortisol, and catecholamine measurements for a noninvasive assessment of stress responses in dogs. *Hormones and Behavior*, *30*(3), 272-279.

Beerda, B., Schilder, M. B., van Hooff, J. A., & de Vries, H. W. (1997). Manifestations of chronic and acute stress in dogs. *Applied Animal Behaviour Science*, *52*(3-4), 307-319.

Beerda, B., Schilder, M. B., van Hooff, J. A., De Vries, H. W., & Mol, J. A. (1999). Chronic stress in dogs subjected to social and spatial restriction. I. Behavioral responses. *Physiology & Behavior*, *66*(2), 233-242.

Beerda, B., Schilder, M. B., Van Hooff, J. A., De Vries, H. W., & Mol, J. A. (2000). Behavioural and hormonal indicators of enduring environmental stress in dogs. *Animal Welfare*, *9*(1), 49-62.

Bergamasco, L., Osella, M. C., Savarino, P., Larosa, G., Ozella, L., Manassero, M., ... & Re, G. (2010). Heart rate variability and saliva cortisol assessment in shelter dog: human–animal interaction effects. *Applied Animal Behaviour Science*, *125*(1), 56-68.

Bennett, P. C., & Rohlf, V. I. (2007). Owner-companion dog interactions: Relationships between demographic variables, potentially problematic behaviours, training engagement and shared activities. *Applied Animal Behaviour Science, 102*(1), 65-84.

Blackwell, E. J., Bodnariu, A., Tyson, J., Bradshaw, J. W. S., & Casey, R. A. (2010). Rapid shaping of behaviour associated with high urinary cortisol in domestic dogs. *Applied Animal Behaviour Science*, *124*(3), 113-120.

Blackwell, E. J., Twells, C., Seawright, A., & Casey, R. A. (2008). The relationship between training methods and the occurrence of behavior problems, as reported by owners, in a population of domestic dogs. *Journal of Veterinary Behavior: Clinical Applications and Research*, *3*(5), 207-217.

Bollen, K. S., & Horowitz, J. (2008). Behavioral evaluation and demographic information in the assessment of aggressiveness in shelter dogs. *Applied Animal Behaviour Science*, *112*(1), 120-135.

Bowman, A., Dowell, F. J., Evans, N. P., & Scottish, S. P. C. A. (2017). The effect of different genres of music on the stress levels of kennelled dogs. *Physiology & Behavior*, *171*, 207-215.

Bowman, A., Scottish, S. P. C. A., Dowell, F. J., & Evans, N. P. (2015). 'Four Seasons' in an animal rescue centre; Classical music reduces environmental stress in kennelled dogs. *Physiology & Behavior*, *143*, 70-82.

Boyko, A. R., Quignon, P., Li, L., Schoenebeck, J. J., Degenhardt, J. D., Lohmueller, K. E., ... & Auton, A. (2010). A simple genetic architecture underlies morphological variation in dogs. *PLoS Biology*, *8*(8), e1000451.

Brayley, C., & Montrose, V. T. (2016). The effects of audiobooks on the behaviour of dogs at a rehoming kennels. *Applied Animal Behaviour Science*, *174*, 111-115.

Broom, D. M. (1991). Animal welfare: concepts and measurement. *Journal of Animal Science*, *69*(10), 4167-4175.

Brown, W. P., Davidson, J.P., & Zuefle, M. E. (2013). Effects of phenotypic characteristics on the length of stay of dogs at two no kill animal shelters. *Journal of Applied Animal Welfare Science*, *16*(1), 2-18.

Bryce, C. A., & Howland, J. G. (2015). Stress facilitates late reversal learning using a touchscreen-based visual discrimination procedure in male Long Evans rats. *Behavioural brain research*, *278*, 21-28.

Chen, Y., Arsenault, R., Napper, S., & Griebel, P. (2015). Models and methods to investigate acute stress responses in cattle. *Animals*, *5*(4), 1268-1295.

Christian, H. E., Westgarth, C., Bauman, A., Richards, E., Rhodes, R. E., Evenson, K. R., ... & Thorpe Jr, R. J. (2013). Dog ownership and physical activity: A review of the evidence. *School of Nursing Faculty Publications.* Paper 9.

Clark, G. I., & Boyer, W. N. (1993). The effects of dog obedience training and behavioural counselling upon the human-canine relationship. *Applied Animal Behaviour Science*, *37*(2), 147-159.

Clarke, N. M., & Fraser, D. (2013). Animal control measures and their relationship to the reported incidence of dog bites in urban Canadian municipalities. *The Canadian Veterinary Journal*, *54*(2), 145.

Coe, J. B., Young, I., Lambert, K., Dysart, L., Nogueira Borden, L., & Rajić, A. (2014). A scoping review of published research on the relinquishment of companion animals. *Journal of Applied Animal Welfare Science*, *17*(3), 253-273.

Coile, D. C. (2007). *The dog breed bible*. Hauppauge, NY: Barron's Educational Series.

Conrad, C. D. (Ed.). (2011). *The handbook of stress: Neuropsychological effects on thebrain* (Vol. 9). John Wiley & Sons.

Coppinger, R., & Coppinger, L. (2001). *Dogs: A startling new understanding of canine origin, behavior & evolution*. Simon and Schuster.

Coppola, C. L., Enns, R. M., & Grandin, T. (2006). Noise in the animal shelter environment: building design and the effects of daily noise exposure. *Journal of Applied Animal Welfare Science*, *9*(1), 1-7.

Coppola, C. L., Grandin, T., & Enns, R. M. (2006). Human interaction and cortisol: Can human contact reduce stress for shelter dogs? *Physiology & Behavior*, 87(3), 537-541.

Coren, S. (1999). Psychology applied to animal training. In A.M. Stec & D.A. Bernstein (Eds.), *Psychology: Fields of Application* (199-217). Boston: Houghton Mifflin.

Cornelissen, J. M., & Hopster, H. (2010). Dog bites in the Netherlands: A study of victims, injuries, circumstances and aggressors to support evaluation of breed specific legislation. *The Veterinary Journal*, *186*(3), 292-298.

Council, F. A. W. (1992). *The five freedoms*. London: Farm Animal Welfare Council.

Creedon, N., & Súilleabháin, P. S. Ó. (2017). Dog bite injuries to humans and the use of breed-specific legislation: A comparison of bites from legislated and non-legislated dog breeds. *Irish Veterinary Journal*, *70*(1), 23.

Curb, L. A., Abramson, C. I., Grice, J. W., & Kennison, S. M. (2013). The relationship between personality match and pet satisfaction among dog owners. *Anthrozoös*, *26*(3), 395-404.

Cutt, H., Giles-Corti, B., & Knuiman, M. (2008). Encouraging physical activity through dog-walking: Why don't some owners walk with their dog? *Preventive Medicine*, *46*(2), 120-126.

Degeling, C., Burton, L., & McCormack, G. R. (2012). An investigation of the association between socio-demographic factors, dog-exercise requirements, and the amount of walking dogs receive. *Canadian Journal of Veterinary Research*, *76*(3), 235.

Degeling, C., & Rock, M. (2013). 'It was not just a walking experience': Reflections on the role of care in dog-walking. *Health Promotion International*, *28*(3), 397-406.

Del Giudice, M., Ellis, B. J., & Shirtcliff, E. A. (2011). The adaptive calibration model of stress responsivity. *Neuroscience & Biobehavioral Reviews*, *35*(7), 1562-1592.

Denham, H. D., Bradshaw, J. W., & Rooney, N. J. (2014). Repetitive behaviour in kennelled domestic dog: Stereotypical or not?. *Physiology & Behavior*, *128*, 288-294.

Diesel, G., Brodbelt, D., & Pfeiffer, D. U. (2010). Characteristics of relinquished dogs and their owners at 14 rehoming centers in the United Kingdom. *Journal of Applied Animal Welfare Science*, *13*(1), 15-30.

Diesel, G., Pfeiffer, D. U., & Brodbelt, D. (2008). Factors affecting the success of rehoming dogs in the UK during 2005. *Preventive Veterinary Medicine*, *84*(3-4), 228-241.

Diesel, G., Smith, H., & Pfeiffer, D. U. (2007). Factors affecting time to adoption of dogs re-homed by a charity in the UK. *Animal Welfare*, *16*(3), 353-360.

Dolan, E. D., Scotto, J., Slater, M., & Weiss, E. (2015). Risk factors for dog relinquishment to a Los Angeles municipal animal shelter. *Animals*, *5*(4), 1311-1328.

Dotson, M. J., & Hyatt, E. M. (2008). Understanding dog–human companionship. *Journal of Business Research*, *61*(5), 457-466.

Dowling-Guyer, S., Marder, A., & D'Arpino, S. (2011). Behavioral traits detected in shelter dogs by a behavior evaluation. *Applied Animal Behaviour Science*, *130*(3), 107-114.

Dudley, E. S., Schiml, P. A., & Hennessy, M. B. (2015). Effects of repeated petting sessions on leukocyte counts, intestinal parasite prevalence, and plasma cortisol concentration of dogs housed in a county animal shelter. *Journal of the American Veterinary Medical Association*, *247*(11), 1289-1298.

Duffy, D. L., Hsu, Y., & Serpell, J. A. (2008). Breed differences in canine aggression. *Applied Animal Behaviour Science*, *114*(3), 441-460.

Duffy, D. L., Kruger, K. A., & Serpell, J. A. (2014). Evaluation of a behavioral assessment tool for dogs relinquished to shelters. *Preventive Veterinary Medicine*, *117*(3-4), 601-609.

Duxbury, M. M., Jackson, J. A., Line, S. W., & Anderson, R. K. (2003). Evaluation of association between retention in the home and attendance at puppy socialization classes. *Journal of the American Veterinary Medical Association*, *223*(1), 61–66.

Ehrich, M., Nelson, M. R., Stanssens, P., Zabeau, M., Liloglou, T., Xinarianos, G., ... & van den Boom, D. (2005). Quantitative high-throughput analysis of DNA methylation patterns by base-specific cleavage and mass spectrometry. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(44), 15785-15790.

European Pet Food Industry Federation. (2014). *Facts and Figures 2014* Available at: https://www.fediaf.org/facts-figures. Accessed June 23, 2016.

Fehringer, A. A. (2014). *Stress in shelter dogs and the use of foster care to improve animal welfare* (Baccalaureate dissertation, The Pennsylvania State University).

Furchgott, R. F. (1959). The receptors for epinephrine and norepinephrine (adrenergic receptors). *Pharmacological Reviews*, *11*(2), 429-441.

Goldstein, D. S., & Kopin, I. J. (2007). Evolution of concepts of stress. *Stress*, *10*(2), 109-120.

Goldstein, D. S., & Kopin, I. J. (2008). Adrenomedullary, adrenocortical, and sympathoneural responses to stressors: A meta-analysis. *Endocrine Regulations*, *42*(4), 111.

Graham, L., Wells, D. L., & Hepper, P. G. (2005a). The influence of visual stimulation on the behaviour of dogs housed in a rescue shelter. *Animal Welfare*, *14*(2), 143-148.

Graham, L., Wells, D. L., & Hepper, P. G. (2005b). The influence of olfactory stimulation on the behaviour of dogs housed in a rescue shelter. *Applied Animal Behaviour Science*, *91*(1), 143-153.

Graybeal, C., Feyder, M., Schulman, E., Saksida, L. M., Bussey, T. J., Brigman, J. L., & Holmes, A. (2011). Paradoxical reversal learning enhancement by stress or prefrontal cortical damage: Rescue with BDNF. *Nature Neuroscience*, *14*(12), 1507.

Gunter, L. M., Barber, R. T., & Wynne, C. D. (2016). What's in a name? Effect of breed perceptions & labeling on attractiveness, adoptions & length of stay for pit-bull-type dogs. *PloS one*, *11*(3), e0146857.

Gunter, L., Protopopova, A., Hooker, S. P., Der Ananian, C., & Wynne, C. D. (2017). Impacts of encouraging dog walking on returns of newly adopted dogs to a shelter. *Journal of Applied Animal Welfare Science*, *20*(4), 357-371.

Hekman, J. P., Karas, A. Z., & Dreschel, N. A. (2012). Salivary cortisol concentrations and behavior in a population of healthy dogs hospitalized for elective procedures. *Applied Animal Behaviour Science*, *141*(3), 149-157.

Haverbeke, A., Pluijmakers, J., & Diederich, C. (2015). Behavioral evaluations of shelter dogs: Literature review, perspectives, and follow-up within the European member states's legislation with emphasis on the Belgian situation. *Journal of Veterinary Behavior: Clinical Applications and Research*, *10*(1), 5-11.

Hennessy, M. B. (2013). Using hypothalamic–pituitary–adrenal measures for assessing and reducing the stress of dogs in shelters: A review. *Applied Animal Behaviour Science*, *149*(1), 1-12.

Hennessy, M. B., Davis, H. N., Williams, M. T., Mellott, C., & Douglas, C. W. (1997). Plasma cortisol levels of dogs at a county animal shelter. *Physiology & Behavior*, *62*(3), 485-490.

Hennessy, M. B., Morris, A., & Linden, F. (2006). Evaluation of the effects of a socialization program in a prison on behavior and pituitary–adrenal hormone levels of shelter dogs. *Applied Animal Behaviour Science*, *99*(1), 157-171.

Hennessy, M. B., Voith, V. L., Young, T. L., Hawke, J. L., Centrone, J., McDowell, A. L., ... & Davenport, G. M. (2002). Exploring human interaction and diet effects on the behavior of dogs in a public animal shelter. *Journal of Applied Animal Welfare Science*, *5*(4), 253-273.

Hennessy, M. B., Williams, M. T., Miller, D. D., Douglas, C. W., & Voith, V. L. (1998). Influence of male and female petters on plasma cortisol and behaviour: Can human interaction reduce the stress of dogs in a public animal shelter? *Applied Animal Behaviour Science*, *61*(1), 63-77.

Herron, M. E., Kirby-Madden, T. M., & Lord, L. K. (2014). Effects of environmental enrichment on the behavior of shelter dogs. *Journal of the American Veterinary Medical Association*, *244*(6), 687-692.

Herron, M. E., Lord, L. K., Hill, L. N., & Reisner, I. R. (2007). Effects of preadoption counseling for owners on house-training success among dogs acquired from shelters. *Journal of the American Veterinary Medical Association*, *231*(4), 558-562.

Herron, M. E., Lord, L. K., & Husseini, S. E. (2014). Effects of preadoption counseling on the prevention of separation anxiety in newly adopted shelter dogs. *Journal of Veterinary Behavior: Clinical Applications and Research*, *9*(1), 13-21.

Hetts, S., Clark, J. D., Calpin, J. P., Arnold, C. E., & Mateo, J. M. (1992). Influence of housing conditions on beagle behaviour. *Applied Animal Behaviour Science*, *34*(1-2), 137-155.

Hewison, L. F., Wright, H. F., Zulch, H. E., & Ellis, S. L. (2014). Short term consequences of preventing visitor access to kennels on noise and the behaviour and physiology of dogs housed in a rescue shelter. *Physiology & Behavior*, *133*, 1-7.

Hewson, C. J., Hiby, E. F., & Bradshaw, J. W. S. (2007). Assessing quality of life in companion and kennelled dogs: A critical review. *Animal Welfare*, *16*(2), 89-95.

Hiby, E. F., Rooney, N. J., & Bradshaw, J. W. (2006). Behavioural and physiological responses of dogs entering re-homing kennels. *Physiology & Behavior*, *89*(3), 385-391.

Hoerster, K. D., Mayer, J. A., Sallis, J. F., Pizzi, N., Talley, S., Pichon, L. C., & Butler, D. A. (2011). Dog walking: Its association with physical activity guideline adherence and its correlates. *Preventive Medicine*, *52*(1), 33-38.

Hoffman, C. L., Harrison, N., Wolff, L., & Westgarth, C. (2014). Is that dog a pit bull? A cross-country comparison of perceptions of shelter workers regarding breed identification. *Journal of Applied Animal Welfare Science*, *17*(4), 322-339.

Houpt, K. A., Honig, S. U., & Reisner, I. R. (1996). Breaking the human-companion animal bond. *Journal of the American Veterinary Medical Association*, *208*(10), 1653.

Hubrecht, R. C. (1995). Enrichment in puppyhood and its effects on later behavior of dogs. *Laboratory Animal Science*, *45*(1), 70-75.

Hubrecht, R. C., Serpell, J. A., & Poole, T. B. (1992). Correlates of pen size and housing conditions on the behaviour of kennelled dogs. *Applied Animal Behaviour Science*, *34*(4), 365-383.

Hubrecht, R., Wickens, S. & Kirkwood, J. (1995). The welfare of dogs in human care. In *The Domestic Dog* (pp. 180-198). Cambridge University Press, Cambridge.

Humane Society of the United States. (n.d.). *Pets by the numbers.* Available at: https://www.humanesociety.org/issues/pet_overpopulation/facts/pet_ownership_statistics.html. Accessed July 7, 2016.

Irion, D. N., Schaffer, A. L., Famula, T. R., Eggleston, M. L., Hughes, S. S., & Pedersen, N. C. (2003). Analysis of genetic variation in 28 dog breed populations with 100 microsatellite markers. *Journal of Heredity*, *94*(1), 81-87.

Jagoe, A., & Serpell, J. (1996). Owner characteristics and interactions and the prevalence of canine behaviour problems. *Applied Animal Behaviour Science*, *47*(1), 31-42.

Joëls, M., Pu, Z., Wiegert, O., Oitzl, M. S., & Krugers, H. J. (2006). Learning under stress: How does it work? *Trends in Cognitive Sciences*, *10*(4), 152-158.

Kass, P. H., Johnson, K. L., & Weng, H. Y. (2013). Evaluation of animal control measures on pet demographics in Santa Clara County, California, 1993–2006. *PeerJ*, *1*, e18.

Kiddie, J., Bodymore, A., & Dittrich, A. (2017). Environmental Enrichment in Kennelled Pit Bull Terriers (*Canis lupus familiaris*). *Animals*, *7*(4), 27.

Kikkawa, A., Uchida, Y., Suwa, Y., & Taguchi, K. (2005). A novel method for estimating the adaptive ability of guide dogs using salivary sIgA. *Journal of Veterinary Medical Science*, *67*(7), 707-712.

Kim, Y. M., Kim, S. A., Lee, S. M., Choi, Y. J., Kim, B. J., & Shin, N. S. (2010). Canine behavioral problems and their effect on relinquishment of the Jindo dog. *Journal of Veterinary Science*, *11*(4), 345-350.

King, T., Marston, L. C., & Bennett, P. C. (2012). Breeding dogs for beauty and behaviour: Why scientists need to do more to develop valid and reliable behaviour assessments for dogs kept as companions. *Applied Animal Behaviour Science*, *137*(1), 1-12.

Kobelt, A. J., Hemsworth, P. H., Barnett, J. L. and Coleman, G. J. (2003) A survey of dog ownership in suburban Australia – conditions and behaviour problems. *Applied Animal Behaviour Science*, *82*(2), 137-148.

Kogan L. R., Ruch-Gallie, R., and Salman, M. D. (2000, August) *Keeping spot at home: An epidemiological approach to maintaining the human-animal bond through behavior education and obedience training*. Paper presented at the 9th International Symposium on Veterinary, Epidemiology and Economics, Breckenridge, Colorado.

Kogan, L. R., Schoenfeld-Tacher, R., & Simon, A. A. (2012). Behavioral effects of auditory stimulation on kenneled dogs. *Journal of Veterinary Behavior: Clinical Applications and Research*, *7*(5), 268-275.

Koskinen, M. T. (2003). Individual assignment using microsatellite DNA reveals unambiguous breed identification in the domestic dog. *Animal Genetics*, *34*(4), 297 301.

Kutsumi, A., Nagasawa, M., Ohta, M., & Ohtani, N. (2013). Importance of puppy training for future behavior of the dog. *Journal of Veterinary Medical Science*, *75*(2), 141-149.

Kwan, J. Y., & Bain, M. J. (2013). Owner attachment and problem behaviors related to relinquishment and training techniques of dogs. *Journal of Applied Animal Welfare Science*, *16*(2), 168-183.

Lazarus, R. S., Deese, J., & Osler, S. F. (1952). The effects of psychological stress upon performance. *Psychological Bulletin*, *49*(4), 293.

Lepper, M., Kass, P. H., & Hart, L. A. (2002). Prediction of adoption versus euthanasia among dogs and cats in a California animal shelter. *Journal of Applied Animal Welfare Science*, *5*(1), 29-42.

Lindblad-Toh, K., Wade, C. M., Mikkelsen, T. S., Karlsson, E. K., Jaffe, D. B., Kamal, M., ... & Mauceli, E. (2005). Genome sequence, comparative analysis and haplotype structure of the domestic dog. *Nature*, *438*(7069), 803.

Lockwood, R., & Rindy, K. (1997). Are “pit bulls” different? An analysis of the pit bull terrier controversy. *Anthrozoos*, *1*, 2-8.

Lord, L. K., Ingwersen, W., Gray, J. L., & Wintz, D. J. (2009). Characterization of animals with microchips entering animal shelters. *Journal of the American Veterinary Medical Association*, *235*(2), 160-167.

Maddalena, S. D., Zeidman, S., & Campbell, K. (2012, November). *An empirical look at public perceptions and attitudes about pet adoption and spay/neuter*. Paper presented at the meeting of the Society of Animal Welfare Administrators, St. Petersburg, Florida.

Maricopa Association of Governments. (2015). *Regional fast facts population & growth.* Available at: https://www.azmag.gov/Documents/FF_POP-GROWTH.pdf. Accessed January 28, 2016.

Mariti, C., Ciceroni, C., & Sighieri, C. (2015). Italian breed-specific legislation on potentially dangerous dogs (2003): Assessment of its effects in the city of Florence (Italy). *Dog Behavior*, *1*(2), 25-31.

Marston, L. C., Bennett, P. C., & Coleman, G. J. (2004). What happens to shelter dogs? An analysis of data for 1 year from three Australian shelters. *Journal of Applied Animal Welfare Science*, *7*(1), 27-47.

Marston, L. C., Bennett, P. C., & Coleman, G. J. (2005). Adopting shelter dogs: Owner experiences of the first month post-adoption. *Anthrozoös*, 18(4), 358-378.

Mason, G. J., & Mendl, M. (1993). Why is there no simple way of measuring animal welfare? *Animal Welfare, 2*, 301-319

Masters, A. M., & McGreevy, P. D. (2008). Dogkeeping practices as reported by readers of an Australian dog enthusiast magazine. *Australian Veterinary Journal*, *86*(1-2), 18-25.

McCobb, E. C., Patronek, G. J., Marder, A., Dinnage, J. D., & Stone, M. S. (2005). Assessment of stress levels among cats in four animal shelters. *Journal of the American Veterinary Medical Association*, *226*(4), 548-555.

McCullough, A., Jenkins, M. A., Ruehrdanz, A., Gilmer, M. J., Olson, J., Pawar, A., ... & Grossman, N. J. (2018). Physiological and behavioral effects of animal-assisted interventions on therapy dogs in pediatric oncology settings. *Applied Animal Behaviour Science*, *200*, 86-95.

McEwen, B. S. (2000). The neurobiology of stress: from serendipity to clinical relevance. *Brain Research*, *886*(1-2), 172-189.

McGowan, R. T., Bolte, C., Barnett, H. R., Perez-Camargo, G., & Martin, F. (2018). Can you spare 15 minutes? The measurable positive impact of a 15-minute petting session on shelter dog well-being. *Applied Animal Behaviour Science*.

McMillan, F. D., Duffy, D. L., Zawistowski, S. L., & Serpell, J. A. (2015). Behavioral and psychological characteristics of canine victims of abuse. *Journal of Applied Animal Welfare Science*, *18*(1), 92-111.

Mendl, M. (1999). Performing under pressure: Stress and cognitive function. *Applied Animal Behaviour Science*, *65*(3), 221-244.

Menor-Campos, D. J., Molleda-Carbonell, J. M., & López-Rodríguez, R. (2011). 714701. Effects of exercise and human contact on animal welfare in a dog shelter. *The Veterinary Record*, *169*(15), 388-388.

Mertens, P. A., & Unshelm, J. (1996). Effects of group and individual housing on the behavior of kennelled dogs in animal shelters. *Anthrozoös*, *9*(1), 40-51.

Meyer, I., & Forkman, B. (2014). Dog and owner characteristics affecting the dog-owner relationship. *Journal of Veterinary Behavior: Clinical Applications and Research,* 9(4), 143-150.

Mohan-Gibbons, H., Weiss, E., Garrison, L., & Allison, M. (2014). Evaluation of a novel dog adoption program in two US communities. *PLoS one, 9*(3): e91959.

Mondelli, F., Prato Previde, E., Verga, M., Levi, D., Magistrelli, S., & Valsecchi, P. (2004). The bond that never developed: Adoption and relinquishment of dogs in a rescue shelter. *Journal of Applied Animal Welfare Science*, *7*(4), 253-266.

Mornement, K. M., Coleman, G. J., Toukhsati, S., & Bennett, P. C. (2010). A review of behavioral assessment protocols used by Australian animal shelters to determine the adoption suitability of dogs. *Journal of Applied Animal Welfare Science*, *13*(4), 314-329.

Morris, K. N., & Gies, D. L. (2014). Trends in intake and outcome data for animal shelters in a large US metropolitan area, 1989 to 2010. *Journal of Applied Animal Welfare Science*, *17*(1), 59-72.

Morrison, R., Penpraze, V., Beber, A., Reilly, J. J., & Yam, P. S. (2013). Associations between obesity and physical activity in dogs: a preliminary investigation. *Journal of Small Animal Practice*, *54*(11), 570-574.

National Animal Interest Alliance. (2015). *Survey of shelter dog composition: Mutts vs. purebreds*. Available at: https:// http://shelterproject.naiaonline.org/purebred/. Accessed August 8, 2016.

Negi, C. S. (2009). *Introduction to endocrinology*. PHI Learning Pvt. Ltd..

Nesse, R. M., & Young, E. A. (2000). Evolutionary origins and functions of the stress response. *Encyclopedia of Stress*, *2*, 79-84.

New Jr., 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 US pet-owning households. *Journal of Applied Animal Welfare Science, 3*(3), 179-201.

New Jr., J. C., Salman, M. D., Scarlett, J. M., Kass, P. H., Vaughn, J. A., Scherr, S., & Kelch, W. J. (1999). Moving: Characteristics of dogs and cats and those relinquishing them to 12 US animal shelters. *Journal of Applied Animal Welfare Science*, *2*(2), 83-96.

Newberry, R. C. (1995). Environmental enrichment: increasing the biological relevance of captive environments. *Applied Animal Behaviour Science*, *44*(2), 229-243.

Newell, D., & Beyer, R. (2012). Increasing compliance toward home exercise in chiropractic patients using SMS texting: A pilot study. *Clinic Chiropractic, 15*, 107-111.

Newbury, S., Blinn, M. K., Bushby, P. A., Cox, C. B., Dinnage, J. D., Griffin, B., ... & O'Quin, J. (2010). Guidelines for standards of care in animal shelters. *The Association of Shelter Veterinarians*, 1-64.

Normando, S., Stefanini, C., Meers, L., Adamelli, S., Coultis, D., & Bono, G. (2006). Some factors influencing adoption of sheltered dogs. *Anthrozoös*, *19*(3), 211-224.

O'Leary, A. (1990). Stress, emotion, and human immune function. *Psychological Bulletin*, 108(3), 363.

Olson, K. R., Levy, J. K., Norby, B., Crandall, M. M., Broadhurst, J. E., Jacks, S., ... & Zimmerman, M. S. (2015). Inconsistent identification of pit bull-type dogs by shelter staff. *The Veterinary Journal*, *206*(2), 197-202.

Olson, P. N., Moulton, C., Nett, T. M., & Salman, M. D. (1991). Pet overpopulation: A challenge for companion animal veterinarians in the 1990s. *Journal of the American Veterinary Medical Association*, *198*(7), 1151.

Overall, K. L. (2015). The mismeasure of behavior: Identifying tests meaningful to the species studied. *Journal of Veterinary Behavior: Clinical Applications and Research*, *10*(1), 1-4.

Owczarczak-Garstecka, S. C., & Burman, O. H. (2016). Can Sleep and resting behaviours be used as indicators of welfare in shelter dogs (Canis lupus familiaris)?. *PloS one*, *11*(10), e0163620.

Parker, H. G., Kim, L. V., Sutter, N. B., Carlson, S., Lorentzen, T. D., Malek, T. B., ... & Kruglyak, L. (2004). Genetic structure of the purebred domestic dog. *Science*, *304*(5674), 1160-1164.

Parker, H. G., & Ostrander, E. A. (2005). Canine genomics and genetics: Running with the pack. *PLoS Genetics*, *1*(5), e58.

Part, C. E., Kiddie, J. L., Hayes, W. A., Mills, D. S., Neville, R. F., Morton, D. B., & Collins, L. M. (2014). Physiological, physical and behavioural changes in dogs (*Canis familiaris*) when kennelled: testing the validity of stress parameters. *Physiology & Behavior*, *133*, 260-271.

Patronek, G. J., Beck, A. M., & Glickman, L. T. (1997). Dynamics of dog and cat populations in a community. *Journal of the American Veterinary Medical Association*, *210*(5), 637-642.

Patronek, G. J., & Glickman, L. T. (1994). Development of a model for estimating the size and dynamics of the pet dog population. *Anthrozoös*, *7*(1), 25-42.

Patronek, G. J., Glickman, L. T., Beck, A. M., McCabe, G. P., & Ecker, C. (1996). Risk factors for relinquishment of dogs to an animal shelter. *Journal of the American Veterinary Medical Association*, *209*(3), 572-581.

Patronek, G. J., Glickman, L. T., & Moyer, M. R. (1995). Population dynamics and the risk of euthanasia for dogs in an animal shelter. *Anthrozoös*, *8*(1), 31-43.

Payne, S. W., & Assemi, K. S. (2017). An evaluation of respondent conditioning procedures to decrease barking in an animal shelter. *Pet Behaviour Science*, (3), 19-24.

Pirrone, F., Pierantoni, L., Mazzola, S. M., Vigo, D., & Albertini, M. (2015). Owner and animal factors predict the incidence of, and owner reaction toward, problematic behaviors in companion dogs. *Journal of Veterinary Behavior: Clinical Application and Research*, *10*(4), 295-301.

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology*, *32*(4), 301-318.

Posage, J. M., Bartlett, P. C., & Thomas, D. K. (1998). Determining factors for successful adoption of dogs from an animal shelter. *Journal of the American Veterinary Medical Association*, *213*(4), 478-482.

Protopopova, A. (2016). Effects of sheltering on physiology, immune function, behavior, and the welfare of dogs. *Physiology & Behavior*, *159*, 95-103.

Protopopova, A., Gilmour, A. J., Weiss, R. H., Shen, J. Y., & Wynne, C. D. L. (2012). The effects of social training and other factors on adoption success of shelter dogs. *Applied Animal Behaviour Science*, *142*(1), 61-68.

Protopopova, A., & Gunter, L. M. (2017). Adoption and relinquishment interventions at the animal shelter: A review. *Animal Welfare*, *26*(1), 35-48.

Protopopova, A., Hauser, H., Goldman, K. J., & Wynne, C. D. (2018). The effects of exercise and calm interactions on in-kennel behavior of shelter dogs. *Behavioural Processes*, *146*, 54-60.

Protopopova, A., Hall, N. J., & Wynne, C. D. (2014). Association between increased behavioral persistence and stereotypy in the pet dog. *Behavioural Processes*, *106*, 77-81.

Protopopova, A., Mehrkam, L. R., Boggess, M. M., & Wynne, C. D. L. (2014). In-kennel behavior predicts length of stay in shelter dogs. *PloS one*, *9*(12), e114319.

Protopopova, A., & Wynne, C. D. (2015). Improving in-kennel presentation of shelter dogs through response-dependent and response-independent treat delivery. *Journal of Applied Behavior Analysis*, *48*(3), 590-601.

Rayment, D. J., De Groef, B., Peters, R. A., & Marston, L. C. (2015). Applied personality assessment in domestic dogs: Limitations and caveats. *Applied Animal Behaviour Science*, *163*, 1-18.

Recio, M. R., Mathieu, R., Maloney, R., & Seddon, P. J. (2010). First results of feral cats (*Felis catus*) monitored with GPS collars in New Zealand. *New Zealand Journal of Ecology*, 288-296.

Richards, E. A., McDonough, M. H., Edwards, N. E., Lyle, R. M., & Troped, P. J. (2013). Psychosocial and environmental factors associated with dog-walking. *International Journal of Health Promotion and Education*, 51(4), 198-211.

Rooney, N. J., Gaines, S. A., & Bradshaw, J. W. (2007). Behavioural and glucocorticoid responses of dogs (*Canis familiaris*) to kennelling: Investigating mitigation of stress by prior habituation. *Physiology & Behavior*, *92*(5), 847-854.

Rosado, B., García-Belenguer, S., León, M., Palacio, J. (2009). A comprehensive study of dog bites in Spain, 1995–2004. *The Veterinary Journal*, *179*(3):383-391.

Rothuizen, J., Reul, J. M., Van Sluijs, F. J., Mol, J. A., Rijnberk, A., & de Kloet, E. D. (1993). Increased neuroendocrine reactivity and decreased brain mineralocorticoid receptor-binding capacity in aged dogs. *Endocrinology*, *132*(1), 161-168.

Sacks, J. J., Lockwood, R., Hornreicht, J., & Sattin, R. W. (1996). Fatal dog attacks, 1989-1994. *Pediatrics*, *97*(6), 891-895.

Sacks, J. J., Sattin, R. W., & Bonzo, S. E. (1989). Dog bite-related fatalities from 1979 through 1988. *Journal of the American Medical Association, 262*(11), 1489-1492.

Sacks, J. J., Sinclair, L., Gilchrist, J., Golab, G. C., & Lockwood, R. (2000). Breeds of dogs involved in fatal human attacks in the United States between 1979 and 1998. *Journal of the American Veterinary Medical Association*, *217*(6), 836-840.

Sales, G., Hubrecht, R., Peyvandi, A., Milligan, S., & Shield, B. (1997). Noise in dog kennelling: Is barking a welfare problem for dogs? *Applied Animal Behaviour Science*, 52(3-4), 321-329.

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: Status, limitations, and future directions. *Research Quarterly for Exercise and Sport*, *71*(2), 1-14.

Salman, M. D., New, Jr, J. G., Scarlett, J. M., Kass, P. H., Ruch-Gallie, R., & Hetts, S. (1998). Human and animal factors related to relinquishment of dogs and cats in 12 selected animal shelters in the United States. *Journal of Applied Animal Welfare Science*, *1*(3), 207-226.

Salman, M. D., Hutchison, J., Ruch-Gallie, R., Kogan, L., New Jr, J. C., Kass, P. H., & Scarlett, J. M. (2000). Behavioral reasons for relinquishment of dogs and cats to 12 shelters. *Journal of Applied Animal Welfare Science*, *3*(2), 93-106.

Sanchez, G. (2013). PLS path modeling with R. *Berkeley: Trowchez Editions*.

Sandri, M., Colussi, A., Perrotta, M. G., & Stefanon, B. (2015). Salivary cortisol concentration in healthy dogs is affected by size, sex, and housing context. *Journal of Veterinary Behavior: Clinical Applications and Research*, *10*(4), 302-306.

Scarlett, J. (2013). Population statistics. In: L. Miller and S. Zawistowski (Eds.), *Shelter Medicine for Veterinarians and Staff* (pp. 13-20). Blackwell Publishers: Iowa, USA.

Scarlett, J. M., Salman, M. D., New, Jr, J. G., & Kass, P. H. (1999). Reasons for relinquishment of companion animals in US animal shelters: Selected health and personal issues. *Journal of Applied Animal Welfare Science*, *2*(1), 41-57.

Scheibeck, R., Pallauf, M., Stellwag, C., & Seeberger, B. (2011). Elderly people in many respects benefit from interaction with dogs. *European Journal of Medical Research*, *16*(12), 557.

Scheifele, P., Martin, D., Clark, J. G., Kemper, D., & Wells, J. (2012). Effect of kennel noise on hearing in dogs. *American Journal of Veterinary Research*, 73(4), 482-489.

Sec. 5-17. Legislative intent, Miami-Dade County, Florida, Code of Ordinances. 89-22, § 2; 89-22, § 3; 89-22, § 5; 89-127, § 1; 89-22, § 8; 89-22, § 7; 89-63, § 1; 99-159, § 1 (1989 & 1999).

Sec. 8-55. Pit bulls prohibited, City and County of Denver, Colorado, Code of Ordinances. 404-89, § 1; 631-89, § 1; 1110-96, § 1 (1989 & 1996).

Sec. 43. Definition of pit bull, City and County of San Francisco, California, Municipal Code. 268-05, File No. 051607 (2005).

Segurson, S. A., Serpell, J. A., & Hart, B. L. (2005). Evaluation of a behavioral assessment questionnaire for use in the characterization of behavioral problems of dogs relinquished to animal shelters. *Journal of the American Veterinary Medical Association*, *227*(11), 1755-1761.

Serpell, J. A. (1996). Evidence for an association between pet behavior and owner attachment levels. *Applied Animal Behaviour Science*, *47*(1), 49-60.

Shiverdecker, M. D., Schiml, P. A., & Hennessy, M. B. (2013). Human interaction moderates plasma cortisol and behavioral responses of dogs to shelter housing. *Physiology & Behavior*, *109*, 75-79.

Shore, E. R. (2005). Returning a recently adopted companion animal: Adopters' reasons for and reactions to the failed adoption experience. *Journal of Applied Animal Welfare Science*, *8*(3), 187-198.

Shore, E. R., Burdsal, C., & Douglas, D. K. (2008). Pet owners' views of pet behavior problems and willingness to consult experts for assistance. *Journal of Applied Animal Welfare Science*, *11*(1), 63-73.

Shore, E. R., Petersen, C. L., & Douglas, D. K. (2003). Moving as a reason for pet relinquishment: A closer look. *Journal of Applied Animal Welfare Science*, *6*(1), 39-52.

Siettou, C., Fraser, I. M., & Fraser, R. W. (2014). Investigating some of the factors that influence “consumer” choice when adopting a shelter dog in the United Kingdom. *Journal of Applied Animal Welfare Science*, *17*(2), 136-147.

Simmons, K. E., & Hoffman, C. L. (2016). Dogs on the move: Factors impacting animal shelter and rescue organizations’ decisions to accept dogs from distant locations. *Animals*, *6*(2), 11.

Snyder, K., Wang, W. W., Han, R., McFadden, K., & Valentino, R. J. (2012). Corticotropin-releasing factor in the norepinephrine nucleus, locus coeruleus, facilitates behavioral flexibility. *Neuropsychopharmacology*, *37*(2), 520.

Stander, M. H. (2014). *Q&A discussion between Alan Kalter, chairman of the board of AKC and Matthew H. Stander of* Dog News. *Dog News*, 44-45.

Stavisky, J., Brennan, M. L., Downes, M., & Dean, R. (2012). Demographics and economic burden of un-owned cats and dogs in the UK: Results of a 2010 census. *BMC Veterinary Research*, *8*(1), 163.

Stephen, J., & Ledger, R. (2007). Relinquishing dog owners' ability to predict behavioural problems in shelter dogs post adoption. *Applied Animal Behaviour Science*, *107*(1), 88-99.

Takahashi, Aki, Shigeru Uchiyama, Yuya Kato, Teruko Yuhi, Hiromi Ushijima, Makoto Takezaki, Toshihiro Tominaga et al. "Immunochromatographic assay using gold nanoparticles for measuring salivary secretory IgA in dogs as a stress marker." *Science and technology of advanced materials* 10, no. 3 (2009): 034604.

Taylor, K. D., & Mills, D. S. (2007). The effect of the kennel environment on canine welfare: A critical review of experimental studies. *Animal Welfare*, 16(4), 435.

Thorn, J. M., Templeton, J. J., Van Winkle, K. M., & Castillo, R. R. (2006). Conditioning shelter dogs to sit. *Journal of Applied Animal Welfare Science*, *9*(1), 25-39.

Titulaer, M., Blackwell, E. J., Mendl, M., & Casey, R. A. (2013). Cross sectional study comparing behavioural, cognitive and physiological indicators of welfare between short and long term kennelled domestic dogs. *Applied Animal Behaviour Science*, *147*(1), 149-158.

Tod, E., Brander, D., & Waran, N. (2005). Efficacy of dog appeasing pheromone in reducing stress and fear related behaviour in shelter dogs. *Applied Animal Behaviour Science*, *93*(3), 295-308.

Tuber, D. S., Hennessy, M. B., Sanders, S., & Miller, J. A. (1996). Behavioral and glucocorticoid responses of adult domestic dogs (*Canis familiaris*) to companionship and social separation. *Journal of Comparative Psychology*, *110*(1), 103.

United States Department of Labor, Occupational Health and Safety Administration. (1983). Occupational noise exposure: Hearing Conservation Amendment, final rule. *Federal Register*, 48, 9738-9785.

Ursin, H., & Eriksen, H. R. (2004). The cognitive activation theory of stress. *Psychoneuroendocrinology*, *29*(5), 567-592.

Vaysse, A., Ratnakumar, A., Derrien, T., Axelsson, E., Pielberg, G. R., Sigurdsson, S., ... & Karlsson, E. K. (2011). Identification of genomic regions associated with phenotypic variation between dog breeds using selection mapping. *PLoS Genetics*, *7*(10), e1002316.

Venn, R. E. (2013). *Effects of acute and chronic noise exposure on cochlear function and hearing in dogs* (Doctoral dissertation, University of Glasgow).

Voith, V., Ingram, E., Mitsouras, K., & Irizarry, K. (2009). Comparison of adoption agency breed identification and DNA breed identification of dogs. *Journal of Applied Animal Welfare Science*, *12*(3), 253-262.

Voith, V. L., Trevejo, R., Dowling-Guyer, S., Chadik, C., Marder, A., Johnson, V., & Irizarry, K. (2013). Comparison of visual and DNA breed identification of dogs and inter-observer reliability. *American Journal of Sociological Research*, *3*(2), 17-29.

Vučinić, M., Đorđević, M., Teodorović, R., Janković, L., Radenković-Damnjanović, B., & Radisavljević, K. (2009). Reasons for relinquishment of owned dogs in a municipal shelter in Belgrade. *Acta Veterinaria*, *59*(2-3), 309-317.

Walker, J. K., Waran, N. K., & Phillips, C. J. (2014). The effect of conspecific removal on the behaviour and physiology of pair-housed shelter dogs. *Applied Animal Behaviour Science*, *158*, 46-56.

Walsh, E. A., McBride, A., Bishop, F., & Leyvraz, A. M. (2007). *Influence of breed, handler appearance and people's experience of dogs on their perception of the temperament of a breed of dog in Ireland*. Paper presented at the 16th Annual Meeting of the International Society for Anthrozoology, Toyko, Japan.

Weiss, E., Mohan-Gibbons, H., & Zawistowski, S. (Eds.). (2015). *Animal behavior for shelter veterinarians and staff*. John Wiley & Sons.

Weiss, E., Miller, K., Mohan-Gibbons, H., & Vela, C. (2012). Why did you choose this pet? Adopters and pet selection preferences in five animal shelters in the United States. *Animals*, *2*(2), 144-159.

Weiss, E., Slater, M., Garrison, L., Drain, N., Dolan, E., Scarlett, J. M., & Zawistowski, S. L. (2014). Large dog relinquishment to two municipal facilities in New York City and Washington, DC: Identifying targets for intervention. *Animals*, *4*(3), 409-433.

Weiss, E., Slater, M., & Lord, L. (2012). Frequency of lost dogs and cats in the United States and the methods used to locate them. *Animals*, *2*(2), 301-315.

Wells, D. L. (2004). The influence of toys on the behaviour and welfare of kennelled dogs. *Animal Welfare*, *13*(3), 367-373.

Wells, D. L., Graham, L., & Hepper, P. G. (2002). The influence of auditory stimulation on the behaviour of dogs housed in a rescue shelter. *Animal Welfare*, *11*(4), 385-393.

Wells, D., & Hepper, P. G. (1992). The behaviour of dogs in a rescue shelter. *Animal Welfare*, *1*(3), 171-186.

Wells, D. L., & Hepper, P. G. (1998). A note on the influence of visual conspecific contact on the behaviour of sheltered dogs. *Applied Animal Behaviour Science*, *60*(1), 83-88.

Wells, D. L., & Hepper, P. G. (2000a). Prevalence of behaviour problems reported by owners of dogs purchased from an animal rescue shelter. *Applied Animal Behaviour Science*, *69*(1), 55-65.

Wells, D. L., & Hepper, P. G. (2000b). The influence of environmental change on the behaviour of sheltered dogs. *Applied Animal Behaviour Science*, *68*(2), 151-162.

Weng, H. Y., Kass, P. H., Chomel, B. B., & Hart, L. A. (2006). Educational intervention on dog sterilization and retention in Taiwan. *Preventive Veterinary Medicine*, *76*(3), 196-210.

Wenstrup, J., & Dowidchuk, A. (1999). Pet overpopulation: Data and measurement issues in shelters. *Journal of Applied Animal Welfare Science*, *2*(4), 303-319.

Westgarth, C., Christian, H. E., & Christley, R. M. (2015). Factors associated with daily walking of dogs. *BMC Veterinary Research*, *11*(1), 116.

White, S. C., Jefferson, E., & Levy, J. K. (2010). Impact of publicly sponsored neutering programs on animal population dynamics at animal shelters: The New Hampshire and Austin experiences. *Journal of Applied Animal Welfare Science*, *13*(3), 191-212.

Zawistowski, S., Morris, J., Salman, M. D., & Ruch-Gallie, R. (1998). Population dynamics, overpopulation, and the welfare of companion animals: New insights on old and new data. *Journal of Applied Animal Welfare Science*, *1*(3), 193-206.

Zeugswetter, F., Bydzovsky, N., Kampner, D., & Schwendenwein, I. (2010). Tailored reference limits for urine corticoid: creatinine ratio in dogs to answer distinct clinical questions. *The Veterinary Record*, *167*(26), 997.

Table 2-1. Breeds and varieties detected in Wisdom Panel 2.0 DogTrax

Affenpinscher, Afghan Hound, Airedale Terrier, Akita, Alaskan Klee Kai, Alaskan Malamute, American Bulldog, American English Coonhound, American Eskimo Dog, American Foxhound, American Hairless Terrier, American Staffordshire Terrier, American Water Spaniel, Anatolian Shepherd Dog, Argentine Dogo, Australian Cattle Dog, Australian Kelpie, Australian Koolie, Australian Shepherd, Australian Terrier, Basenji, Bassett Hound, Beagle, Bearded Collie, Beauceron, Bedlington Terrier, Belgian Malinois, Belgian Sheepdog, Belgian Tervuren, Bergamasco, Berger Picard, Bernese Mountain Dog, Bichon Frise, Black and Tan Coonhound, Black Russian Terrier, Bloodhound, Bluetick Coonhound, Boerboel, Border Collie, Border Terrier, Borzoi, Boston Terrier, Bouvier des Flandres, Boxer, Boykin Spaniel, Briard, Brittany, Brussels Griffon, Bull Terrier (Miniature and Standard), Bulldog, Bullmastiff, Cairn Terrier, Canaan Dog, Cane Corso, Cardigan Welsh Corgi, Catahoula Leopard Dog, Cavalier King Charles Spaniel, Cesky Terrier, Chesapeake Bay Retriever, Chihuahua, Chinese Crested, Chinese Shar-Pei, Chinook, Chow Chow, Cirneco dell'Etna, Clumber Spaniel, Cocker Spaniel, Collie, Coton de Tulear, Curly-Coated Retriever, Dachshund (Standard and Miniature in Shorthair, Longhair, and Wirehair), Dalmatian, Dandie Dinmont Terrier, Doberman Pinscher, Dogue De Bordeaux, English Cocker Spaniel, English Foxhound, English Setter, English Springer Spaniel, English Toy Spaniel, Entlebucher Mountain Dog, Field Spaniel, Finnish Lapphund, Finnish Spitz, Flat-Coated Retriever, Fox Terrier (Smooth, Toy, and Wire), French Bulldog, German Pinscher, German Shepherd Dog, German Shorthaired Pointer, German Spitz, German Wirehaired Pointer, Glen of Imaal Terrier, Golden Retriever, Gordon Setter, Great Dane, Great Pyrenees, Greater Swiss Mountain Dog, Greyhound, Harrier, Havanese, Ibizan Hound, Icelandic Sheepdog, Irish Red and White Setter, Irish Setter, Irish Terrier, Irish Water Spaniel, Irish Wolfhound, Italian Greyhound, Japanese Chin, Japanese Spitz (Klein and Mittel), Jindo, Keeshound, Kerry Blue Terrier, Komondor, Kuvasz, Labrador Retriever, Lagotto Romagnolo, Lakeland Terrier, Lancashire Heeler, Large Münsterlander, Leonberger, Lhasa Apso, Löwchen, Maltese, Manchester Terrier (Standard and Toy), Mastiff, Miniature Pinscher, Neapolitan Mastiff, Newfoundland, Norfolk Terrier, Norwegian Buhund, Norwegian Elkhound, Norwegian Lundehund, Norwich Terrier, Nova Scotia Duck Tolling Retriever, Old English Sheepdog, Otterhound, Papillon, Parson Russell Terrier, Pekingese, Pembroke Welsh Corgi, Petit Basset Griffon Vendeen, Pharaoh Hound, Plott Hound, Pointer, Polish Lowland Sheepdog, Pomeranian, Poodle (Toy, Miniature, and Standard), Portuguese Podengo Pequeno, Portuguese Water Dog, Pug, Puli, Pyrenean Shepherd, Rat Terrier, Redbone Coonhound, Rhodesian Ridgeback, Rottweiler, Russell Terrier, Saint Bernard, Saluki, Samoyed, Schipperke, Schnauzer (Giant, Standard, and Miniature), Scottish Deerhound, Scottish Terrier, Sealyham Terrier, Shetland Sheepdog, Shiba Inu, Shih Tzu, Siberian Husky, Silky Terrier, Skye Terrier, Small Münsterlander, Soft Coated Wheaten Terrier, Spanish Water Dog, Spinone Italiano, Staffordshire Bull Terrier, Sussex Spaniel, Swedish Vallhund, Tibetan Mastiff, Tibetan Spaniel, Tibetan Terrier, Treeing Walker Coonhound, Vizsla, Weimaraner, Welsh Springer Spaniel, Welsh Terrier, West

Highland White Terrier, Whippet, White Swiss Shepherd, Wirehaired Pointing Griffon, Wirehaired Vizsla, Xoloitzcuintli, Yorkshire Terrier

Table 2-2. Number and breeds of purebred dogs at Arizona Animal Welfare League and San Diego Humane Society

Breed	AAWL	SDHS	Total
American Bulldog		1	1
American Staffordshire Terrier	1	4	5
Border Collie		1	1
Boston Terrier		1	1
Boxer	3	1	4
Bulldog		1	1
Chihuahua	1	2	3
Cocker Spaniel		1	1
Doberman Pinscher		1	1
German Shepherd Dog		2	2
Golden Retriever		1	1
Labrador Retriever		5	5
Miniature Pinscher		1	1
Pomeranian	1	1	2
Pug		1	1
Rottweiler	1		1
Russell Terrier		1	1
Saint Bernard	1		1

Schnauzer	1	2	3
Shih Tzu		3	3
Siberian Husky		1	1
Yorkshire Terrier	2	3	5
Total purebreds	11	34	45

Table 2-3. Dogs at Arizona Animal Welfare League and San Diego Humane Society with two purebred parents of different breeds

Breeds	AAWL	SDHS	Total
Chihuahua, Rat Terrier	1	2	3
Chihuahua, Russell Terrier	1		1
Dachshund, Yorkshire Terrier	1		1
Great Dane, Saint Bernard	1		1
Labrador Retriever, Chihuahua		1	1
Pekingese, Rat Terrier	1		1
Poodle, Chihuahua	1		1
Poodle, Schnauzer	1		1
Yorkshire Terrier, Maltese		1	1
Yorkshire Terrier, Poodle	1		1
Total purebred crosses	8	4	12

Table 2-4. Most commonly observed breed signatures at Arizona Animal Welfare League

Breed	Count	% of shelter sample	Avg. concentration (%)
American Staffordshire Terrier	110	24.0	37.4
Chihuahua	110	24.0	38.0
Poodle	70	15.3	32.9
Boxer	51	11.1	34.6
German Shepherd Dog	39	8.5	24.7
Labrador Retriever	37	8.1	20.9
Cocker Spaniel	31	6.8	23.4
Australian Cattle Dog	30	6.5	25.8
Dachshund	27	5.9	20.8
Shih Tzu	25	5.4	29.5
Mixed (beyond three generations)	419	91.3	37.3

Table 2-5. Most commonly observed breed signatures at San Diego Humane Society

Breed	Count	% of shelter sample	Avg. concentration (%)
American Staffordshire Terrier	128	27.8	45.5
Chihuahua	82	17.8	39.6
Poodle	67	14.6	30.6
German Shepherd Dog	55	12.0	30.0
Labrador Retriever	39	8.5	35.9
Boxer	38	8.3	28.6
Cocker Spaniel	34	7.4	25.0
Yorkshire Terrier	30	6.5	41.3
Dachshund	25	5.4	22.0
Maltese	22	4.8	25.6
Mixed (beyond three generations)	388	84.3	37.4

Table 2-6. Length of stay in days for pit bull-type dogs and all other breeds at Arizona Animal Welfare League and San Diego Humane Society

Breed group	Count	Minimum LOS	Maximum LOS	*M*	*SD*
Pit-bull-type dogs	244	1	333	37.5	49.41
AAWL	117	1	333	32.5	49.05
SDHS	127	1	249	42.0	49.49
All other breeds	626	1	260	19.7	25.02
AAWL	328	1	233	20.5	21.57
SDHS	298	1	260	18.9	28.35

Table 2-7. Significance tests for pit bull-type dogs' and all other breeds' length of stay at Arizona Animal Welfare League and San Diego Humane Society

	t-value	df	*M* difference	*95% CI*	
				LL	UL
Overall	5.351**	293	17.751	11.222	24.280
AAWL	2.560*	132	12.001	2.727	21.274
SDHS	4.946**	162	23.188	13.930	32.446

Note. CI = confidence interval; LL = lower limit, UL = upper limit.
* $p < .05$. ** $p < .001$.

Table 2-8. Confusion matrix for pit bull-type dog identification

		Assigned as pit-bull-type by staff		
		Yes	No	Total
Confirmed pit-bull-type by DNA analysis	Yes	87	27	114
	No	4	266	270
	Total	91	293	384

Note. This compares dogs that were assigned a pit bull-type breed by staff and confirmation by DNA analysis for dogs with pit bull-type heritage of 25% or greater.

Table 4-1. Component loadings and communalities based on principal components analysis with Varimax rotation for nine obligation, walking, and behavior answers from Weeks 1 and 4

	Component 1	Component 2	Communalities
I feel an obligation to walk my dog regularly	**0.673**	-0.243	0.512
I enjoy walking my dog	**0.709**	0.127	0.519
I will walk my dog even though I am feeling sad or highly stressed	**0.850**	0.082	0.729
I will walk my dog even when the weather is bad	**0.734**	0.014	0.539
I will set aside time for regularly walking my dog	**0.857**	0.024	0.735
I do/did not have good control over my dog; my dog does/did not listen to me	0.035	**0.774**	0.601
My dog does/did not behave well when on leash (i.e. pulls on leash)	-0.066	**0.856**	0.736
My dog walks/walked too fast for me	-0.013	**0.803**	0.646
My dog is/was too energetic or "hyper"	0.081	**0.780**	0.616

Note. N = 174. Loadings >.3 are in bold.

Table 4-2. Multiple linear regression analysis with backward elimination predicting average weekly walking activity

	B	*SE B*	Β
All variables model:			
(Constant)	235.21	50.78	
Condition	39.71	28.31	0.12
Dog's age	0.02	0.02	0.07
Dog's weight	0.63	0.85	0.06
First-time dog owner	54.79	46.13	0.10
Other dogs in household	-16.10	13.49	-0.10
Owner's age	-1.773	1.05	-0.16
Race: African-American	-143.42	88.85	-0.13
Race: Hispanic	50.63	54.81	0.08
Race: Asian	188.89	98.24	0.15
Race: Native American	261.60	100.43	0.21
Race: Other	141.14	67.08	0.17
Education: Some high school	57.26	101.41	0.05
Education: High school graduate	-12.83	64.33	-0.02
Education: Some college	-5.20	45.91	-0.01
Education: Associate's degree	-31.76	44.87	-0.06
Education: Master's degree	1.33	37.22	0.00
Education: Professional school degree	269.29	164.74	0.13
Education: PhD	-11.66	58.57	-0.02
Annual income	1.39	5.136	0.03
Attended a dog walk	32.09	53.33	0.05
Component loading 1 (Obligation, walking self-efficacy)	-51.57	14.02	-0.30
Component loading 2 (Behavior of the dog on-leash)	-6.25	14.48	-0.04
Returned dog back to shelter	78.05	68.72	0.09
Variable model including all predictors ($p < .09$)			
(Constant)	234.64	17.96	
Other dogs in household	-21.62	12.33	-0.14
Race: Native American*	266.84	95.14	0.22
Race: Other	119.84	63.07	0.15
Component loading 1 (Obligation walking self-efficacy)**	-59.00	13.11	-0.35

Note. * $p < .01$, ** $p < .001$

Table 6-1. Location of shelter, admission type and location, annual intake, subject dogs, and samples collected

Shelter	Admission Type and State	Annual Canine Intake	Subject Dogs	Complete Sequences*	Samples Collected	Samples Removed**
BFAS	Limited, UT	743	39	38	131	3
AHS	Open, AZ	6607	43	32	243	9
HSWM	Limited, MT	847	40	33	235	4
DCAS	Open, GA	5686	43	41	254	8
SPCATX	Limited, TX	4818	42	40	254	17

Note. *Complete sequences are dogs in which all experiment time-points were collected. **Samples were removed from data analysis when C/C ratio values were three standard deviations above the shelter's mean.

Table 6-2. Shelter mean of participating dogs' sex, LOS, age, weight, and cortisol: creatinine ratio values

Shelter	Sex %	LOS (days)		Age (mths)		Weight (kg)		Cortisol: Creatinine Ratio (x 10^{-6})	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
BFAS	M: 61.9	463.46	594.50	63.63	42.50	24.43	5.70	22.03	7.23
AHS	M: 67.4	14.08	9.34	48.95	32.88	19.23	6.00	39.14	17.66
HSWM	M: 53.5	9.67	12.05	32.73	33.38	16.66	11.34	29.23	10.99
DCAS	F: 60.5	59.41	57.38	31.93	23.06	21.42	5.44	26.62	11.78
SPCATX	F: 51.2	22.19	1.49	55.54	28.84	21.16	8.97	22.82	9.94

Table 6-3. Resulting coefficients, standard errors, *t*-test and *p*-values of multiple linear regression analyses with backward elimination predicting cortisol values from sex, age, weight, and LOS at each shelter

	Variable	*B*	*SE B*	*t*-test	*p*-value
BFAS	*Weight*	-.34	.12	-2.92	.035
	Age	.03	.02	2.13	.004
	Previous Sleepovers	-.07	.03	-2.16	.033
AHS	*Weight*	-1.60	.16	-10.11	< .001
	Age	.09	.03	3.17	.002
HSWM	*Weight*	-.28	.07	-4.38	< .001
	Sex	-3.48	1.47	-2.37	.019
	Weight	-.58	.12	-4.87	< .001
DCAS	*Age*	.19	.03	6.95	< .001
	LOS	-.05	.01	-4.68	< .001
SPCATX	*Weight*	-.38	.07	-5.62	< .001
	Age	.08	.02	3.71	< .001

Note. The variable “previous sleepovers” was tested as a predictor only at BFAS. Age was scaled in months.

Table 6-4. Mean cortisol: creatinine ratio value, standard error, F test statistic, and p value for time-points before, during, and after temporary fostering at 5 US shelters

	Before Sleepover (Shelter)				During Sleepover (Foster)				After Sleepover (Shelter)				Test Statistics	
	1		2		3		4		5		6			
Shelter	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE	*F*	*p*
BFAS			20.66[a]	0.98	18.15[a,b]	0.89			21.38[b]	1.25			7.34	.002
AHS	43.53[a]	2.92	44.51[b,c]	2.34	37.23[b]	2.03	32.80[a,c,d]	2.36	40.19[d]	2.30	38.96	1.93	5.79	< .001
HSWM	29.84	1.56	31.50[a]	1.78	26.42[b]	1.74	25.89[a,c,d]	1.69	30.85[c]	1.52	32.59[b,d]	1.70	4.81	.001
DCAS	29.06[a,b]	1.62	28.48[c,d]	1.41	24.54[a,c]	1.48	23.592[b,d]	1.72	28.06	1.49	27.60	1.55	4.13	.003
SPCATX	24.34[a]	1.52	24.67[b]	1.55	22.19	1.49	20.64[a,b,c,d]	1.49	24.49[c]	1.55	24.16[d]	1.40	3.37	.011
Overall			29.73[a]	0.79			24.92[a,b]	0.77			29.19[b]	0.75	31.71	< .001

Note. All shared lettered comparisons are significant at $p = .05$ or less except for DCAS comparison *a* ($p = .063$) and SPCATX comparisons *a* ($p = .072$) and *c* ($p = .067$). Overall means and standard errors before, during, and after sleepover were estimated using 1-day cortisol values at BFAS and 2-day aggregate values at all other shelters.

Table 7-1. Operational definitions of all behaviors coded during the in-kennel observation period

Behavior	*Operational Definition*
Kennel Position	
Front of kennel	Located between front of cage, and up to and including the midpoint of the visible kennel
Back of kennel	Located between back wall of kennel, and up to, but not including, midpoint of the visible kennel
Out of sight	Not visible from the front of the cage, behavior cannot be defined
Body Position	
Sitting	Supported by two extended front legs and two flexed back legs
Standing	Supported upright with all four legs
Cowering	Head and body in a lowered, crouched, or sitting position with head below shoulders
Paw lifting	Raises single forepaw while sitting or standing and holds it above the ground
Lying down, head up	Lying down on ventral or side of body with limbs either tucked or placed in front of body without head making contact with arms, paws, bed, or floor
Lying down, head down	Lying down on ventral or side of body with limbs either tucked or placed in front of body with head resting on limbs, paws, bed, or floor
Beg	2 front paws lifted off the ground simultaneously with no contact to a surface while the back legs remain flexed
Play bowing	Lowered anterior and heightened posterior part while standing on hind legs
Belly up	Rolling onto back, exposing ventral side
Tail Position	
Tucking tail	Tail held still and tightly between hind legs, may be curled under genital area or ventral side
Wagging tail	Tail moves perpendicular to the dog's body
Locomotion	
Walking	Walking or trotting in the kennel in any direction
Jumping on door	Both front paws make contact with the cage door that does not include lunging
Jumping on kennel	Both front paws make contact with kennel that does not include lunging
Lunging	Quick diagonal forward motion; may be accompanied by vocalization
Chasing tail	Orients towards tail repeatedly (more than three times in succession) and continuously
Pacing	Repeatedly (more than three times in succession) locomoting around kennel in fixed route

Vocalization	
Barking	Vocalization of very short duration and low frequency
Howling	Prolonged high-amplitude vocalization of varying pitch, lips drawn together while exhaling
Kennel contact	
Leaning on kennel	Prolonged (more than 1sec) contact with the cage wall by pushing side of body against the kennel wall
Leaning on door	Prolonged (more than 1 sec) contact with the cage door by pushing side of body against the kennel door
Kennel exploration	
Licking door	Chews, licks, and/or bites at the wire of the kennel door
Licking kennel	Chews, licks, and/or bites the walls of the kennel
Pawing at door	One front paw makes contact with the kennel door
Pawing at kennel	One front paw makes contact with kennel (floor or wall)
Sniffing	Muzzle/nose is oriented in a clearly observable direction and motion of nostrils is observed
Manipulating object	Patting, throwing, pouncing, wrestling, and/or chewing object with paws and/or mouth
Grooming	
Scratching	Paw makes repeated contact with body/face; head may be angled in direction of moving limb
Licking self	Oral contact with any part of body
Maintenance	
Yawning	Opens mouth widely and inhales
Stretching	Extending body and one or more front and/or hind legs while remaining stationary
Panting	Tongue exposed with observable breathing
Shaking off	Motions body and/or head back and forth repeatedly and rapidly
Trembling	Visible shaking while dog is standing still or cowering
Lip-licking	Tongue protrudes and dog licks own lips or snout
Ingestion/ Elimination	
Eating	Ingesting food
Drinking	Lapping water
Regurgitating	Matter expelled from mouth with jaws open; may be preceded by repeated abdominal heaving
Coprophagy	Feeding on own/other dogs' feces
Eliminating	A hind-leg lifted or is squatting and urinates or defecates
Kennel Interaction	
Human in kennel	Physical contact with human

Play bowing with dog	Lowered anterior and heightened posterior part (standing on hind legs) with kennelmate
Jumping on dog	Both front paws make contact with kennelmate
Pawing at dog	1 front paw makes contact with kennelmate
Leaning on dog	Prolonged (1+s) contact on kennelmate by pushing any part of subject dog's body (except paws) against it
Barking at dog	Vocalization of very short duration & low frequency towards kennelmate
Manipulating object with dog	Both dogs patting, throwing, pouncing, wrestling, and/or chewing object with their paws and/or mouths
Mounting dog	Subject dog rears up to place front legs on kennelmate's back in front, lateral, or rear mount position which may or may not be accompanied by thrusting
Sniffing dog	Muzzle/nose is oriented toward or upon kennelmate in a clearly observable direction and movement of nose is observed
Licking dog	Chews, licks, and/or bites upon kennelmate
Snapping at dog	Mouth opens and closes, possibly accompanied by showing the teeth, associated with a short lunge forward or a quick head movement, that may or may not result in contact
Receiving behavior	Being jumped upon, play bowed toward, barked at, sniffed upon, pawed at, licked, or snapped at by kennelmate

Table 7-2. Number of dogs, intake type, sex, housing status and mean, standard deviation, and range of weight, age, length of stay, cortisol:creatinine, metanephrine:creatinine, normetanephrine, pulse rate, rest, and cognitive performance

		M	*SD*	Range
Dogs	62			
Intake type	36 Owner-Surrender			
	19 Stray			
	7 Confiscate/Cruelty			
Sex	33 Male			
	29 Female			
Housing status	54 Single			
	8 Pair-Housed			
Weight (kg)		24.55	7.53	3.63 – 42.05
Age (months)		45.47	33.74	6.00 – 168.00
LOS (days)		9.37	9.70	2.00 – 53.00
Cortisol:Creatinine ratio (x 10^{-6})		29.09	13.57	7.40 – 66.35
Metanephrine:Creatinine ratio		85.02	37.98	24.00 – 193.00
Normetanephrine: Creatinine ratio		171.25	62.00	82.00 – 333.00
Average pulse rate (beats per minute)		70.75	9.22	55.00 – 97.67
Longest bout of rest (minutes)		11.84	5.17	2.00 – 24.00
Cognitive Task:				
Prop correct (x100)		46.79	14.80	10.00 – 66.67
Blocks completed		1.91	1.41	0.00 – 6

Table 7-3. Summary of 29 behaviors entered into multiple regression analyses

Behavior	*Proportion that displayed behavior*	*M*	*SD*	*Range*
Kennel Position				
Front of kennel	100	74.41	24.15	3.50 – 99.82
Back of kennel	100	25.42	24.11	0.08 – 96.50
Body Position				
Sitting	98	15.32	12.26	0.0 – 49.51
Standing	100	19.92	16.28	0.20 – 70.21
Paw lifting	45	0.49	1.41	0.0 – 7.48
Lying down, head up	100	19.47	12.46	3.59 – 56.07
Lying down, head down	100	43.35	22.44	0.96 – 87.65
Tail Position				
Wagging tail	88	8.89	11.38	0.0 – 49.26
Locomotion				
Walking	100	2.69	2.43	0.03 – 10.09
Jumping on door	43	0.45	0.78	0.0 – 3.63
Jumping on kennel	47	1.24	4.06	0.0 – 24.86
Vocalization				
Barking (count)	76	238.90	397.11	0.0 – 2049
Howling	7	0.69	2.04	0.0 – 10.71
Kennel contact				
Leaning on kennel	83	24.69	25.45	0.0 – 83.26
Kennel exploration				
Licking door	36	0.25	0.78	0.0 – 4.68
Licking kennel	29	0.04	0.17	0.0 – 1.21
Pawing at door	47	0.22	0.46	0.0 – 2.33
Pawing at kennel	28	0.04	0.16	0.0 – 1.10
Sniffing	97	4.46	6.84	0.0 – 42.50
Manipulating object	62	0.69	1.42	0.0 – 6.63
Grooming				
Scratching	36	0.16	0.32	0.0 – 1.36
Licking Self	84	1.73	1.86	0.0 – 6.45
Maintenance				
Yawning (count)	98	9.86	8.08	0.0 – 47
Stretching	64	0.15	0.25	0.0 – 1.40
Panting	59	9.53	16.92	0.0 – 76.46
Shaking off	62	0.03	0.07	0.0 – 0.46
Lip-licking (count)	100	76.31	56.50	8.0 – 296.0
Ingestion/Elimination				
Eating	29	0.26	1.05	0.0 – 7.73
Drinking	50	0.14	0.23	0.0 – 1.07

Table 7-4. Resulting coefficients, standard errors, *t*-test and *p*-values of multiple linear regression analyses with backward elimination predicting behavioral, pulse rate, and rest variables from physiological measures

	Physiological Measure	*B*	*SE B*	*t*-test	*p*-value
Barking	*M/C*	0.35	0.13	2.71	.009
Drinking	*C/C*	0.29	0.13	2.22	.031
Howling	*M/C*	0.26	0.13	1.93	.059*
Licking on door	NM/C	0.20	0.13	1.51	.137**
Licking on kennel	*C/C*	0.29	0.13	2.18	.034
Licking self	*M/C*	-0.37	0.13	-2.92	.005
Lip licking	*C/C*	0.24	0.12	1.99	.052
	M/C	0.54	0.13	3.99	< .001
	NM/C	-0.40	0.13	-2.93	.005
Lying down, head down	*M/C*	-0.73	0.12	-5.96	< .001
	NM/C	0.50	0.12	4.06	< .001
Manipulating object	*M/C*	-0.25	0.13	-1.90	.063*
Panting	*C/C*	0.41	0.12	3.58	.001
	M/C	0.46	0.13	3.54	.001
	NM/C	-0.32	0.13	-2.40	.020
Pawing at door	*C/C*	0.24	0.13	1.78	.081*
Pawing at kennel	*C/C*	0.36	0.13	2.83	.007
Scratching	*M/C*	-0.19	0.14	-1.44	.156**
Sitting	*M/C*	0.33	0.13	2.55	.014
Standing	*M/C*	0.56	0.14	3.99	< .001
	NM/C	-0.37	0.14	-2.67	.010
Stretching	*C/C*	-0.26	0.13	-1.98	.053
	M/C	-0.26	0.13	-1.98	.055*
Wagging tail	*M/C*	0.34	0.13	2.60	.012
Yawning	*NM/C*	-0.28	0.13	-2.11	.039
Average pulse rate	*M/C*	-0.30	0.13	-2.27	.028
	NM/C	0.61	0.13	4.56	< .001
Longest bout of rest	*M/C*	0.24	0.13	1.84	.071*

Note: The behavior variables of eating; jumping on door; jumping on kennel; back and front of kennel; leaning on kennel; lying down, head up; paw-lifting, shaking off, sniffing, and walking were tested in multiple regression analyses but did not have predictive relationships to any of the physiological measures.

Table 7-5. Multiple linear regression analysis with backwards elimination predicting cognitive performance from behavioral, pulse rate, and rest variables

	Variable	*B*	*SE B*	*t*-test	*p*-value
Proportion correct	*Standing*	0.34	0.15	2.22	.033
Blocks completed	*Licking Self*	-0.32	0.16	-1.98	.054

Table 7-6. Prediction model of path analysis with coefficient estimates, standard errors, *t*-test statistics, and *p*-values for each latent variable & physiological measure

	Estimate	*SE*	*t*-test	*p*-value
Pulse				
Intercept	$7.43e^{-16}$	0.12	$6.04e^{-15}$	1.00
C/C	-0.05	0.13	0.414	.68
M/C	-0.34	0.14	-2.50	.015
NM/C	0.61	0.15	4.23	$< .001$
BG1				
Intercept	$1.00e\text{-}^{16}$	0.12	$8.47e^{-16}$	1.00
C/C	0.28	0.12	2.36	.009
M/C	0.57	0.14	4.11	$< .001$
NM/C	-0.45	0.14	-3.25	.002
BG2				
Intercept	$5.93e^{-17}$	0.13	$4.61e^{-16}$	1.00
C/C	0.22	0.13	1.66	.10
M/C	0.44	0.15	2.94	.005
NM/C	-0.13	0.15	-0.88	.38
BG3				
Intercept	$1.05e\text{-}^{16}$	0.14	$7.82e^{-16}$	1.00
C/C	-0.24	0.14	-1.78	.08
M/C	0.13	0.16	0.83	.41
NM/C	-0.27	0.16	-1.68	.099
BG4				
Intercept	$1.74e\text{-}^{16}$	0.12	$1.44e^{-15}$	1.00
C/C	-0.24	0.12	-1.94	.058
M/C	-0.57	0.14	-4.02	$< .001$
NM/C	0.27	0.14	1.87	.068

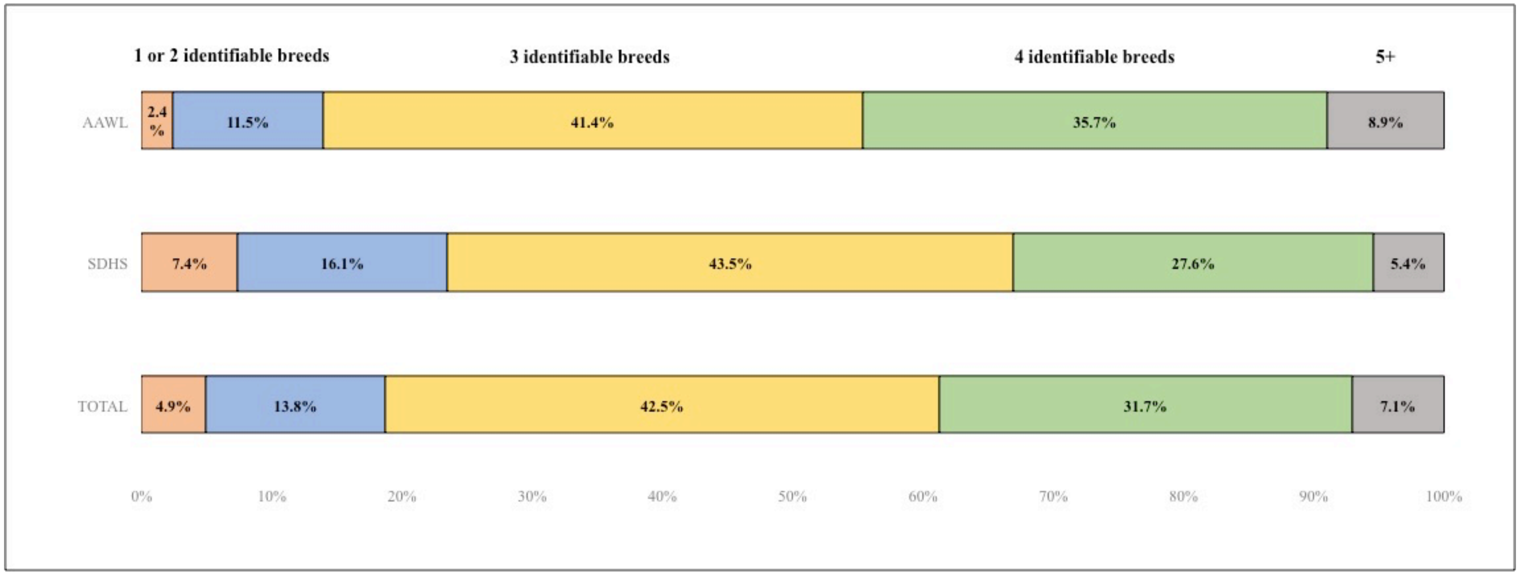

Figure 2-1. Proportion of dogs by number of identifiable breeds within breed heritage at Arizona Animal Welfare League and San Diego Humane Society

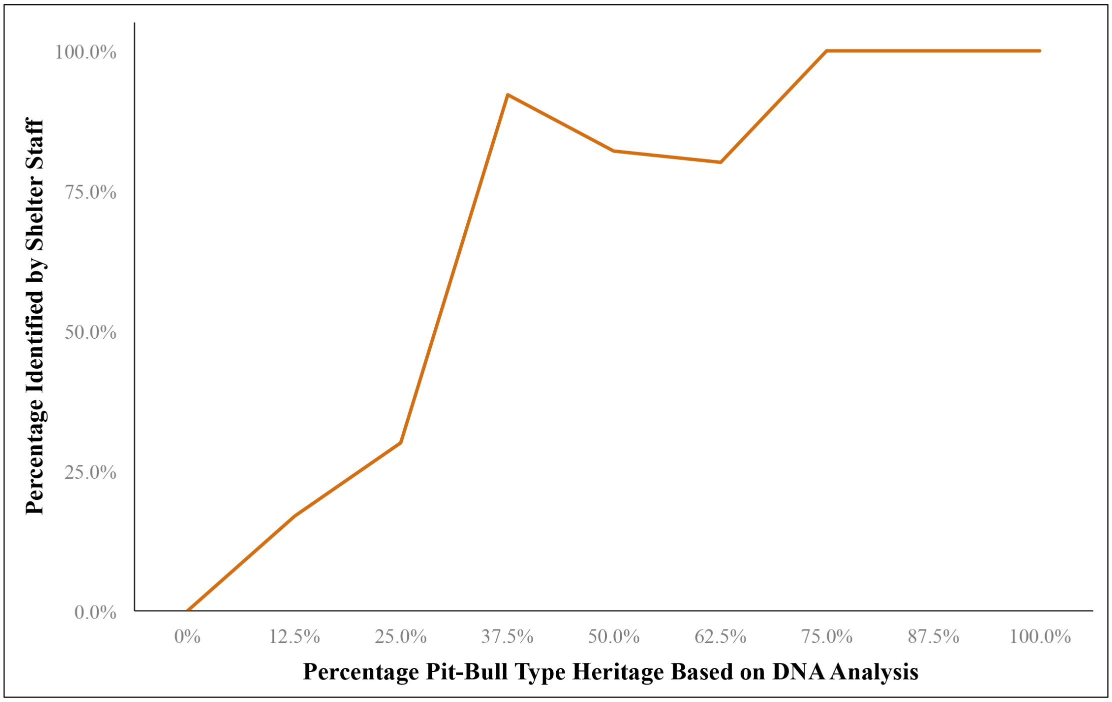

Figure 2-2. Percentage of pit bull-type dogs correctly and incorrectly identified by shelter staff by percentage of pit bull-type heritage. As the number of pit bull-type relatives increased within a dog's breed heritage, the ability of staff to correctly identify the dog as a pit bull-type increased.

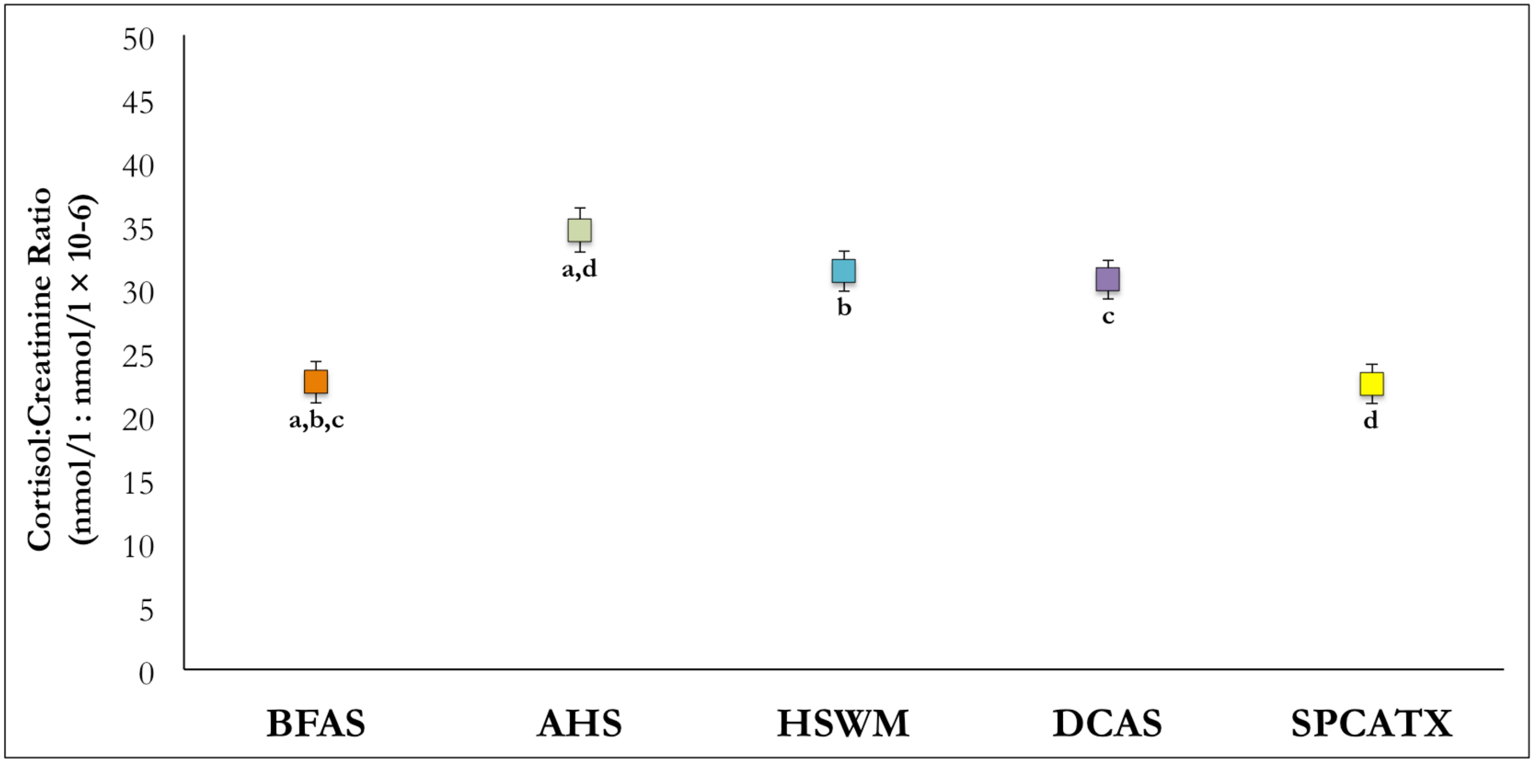

Figure 6-1. Estimated marginal means of average cortisol: creatinine ratio values and standard errors for each shelter. All shared lettered comparisons are significant at $p < .05$.

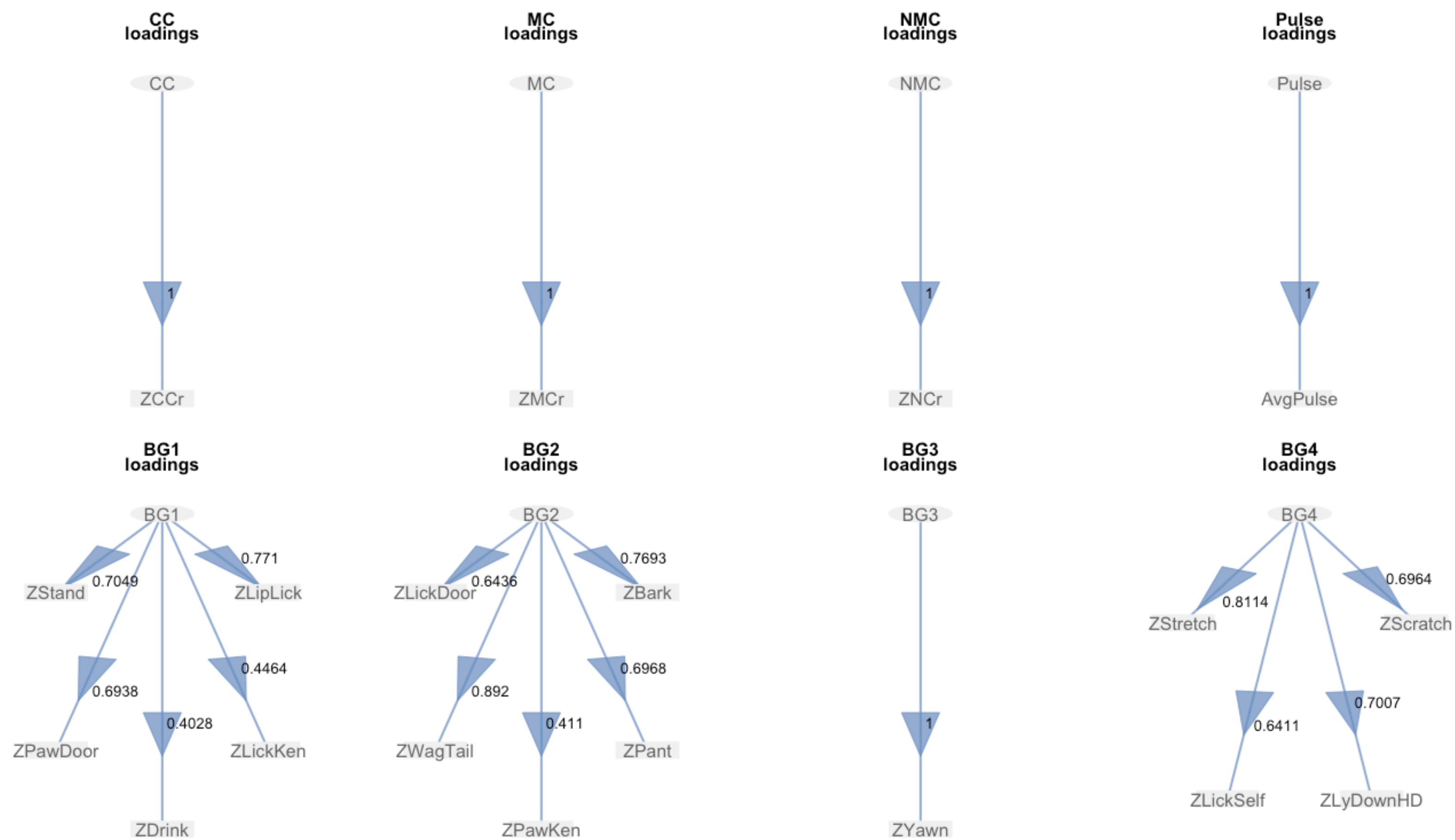

Figure 7-1. Loadings on latent variables, including formative indicators of cortisol: creatinine, metanephrine: creatinine, normetanephrine: creatinine, and pulse rate, and reflective indicators on Behavior Groups 1-4.

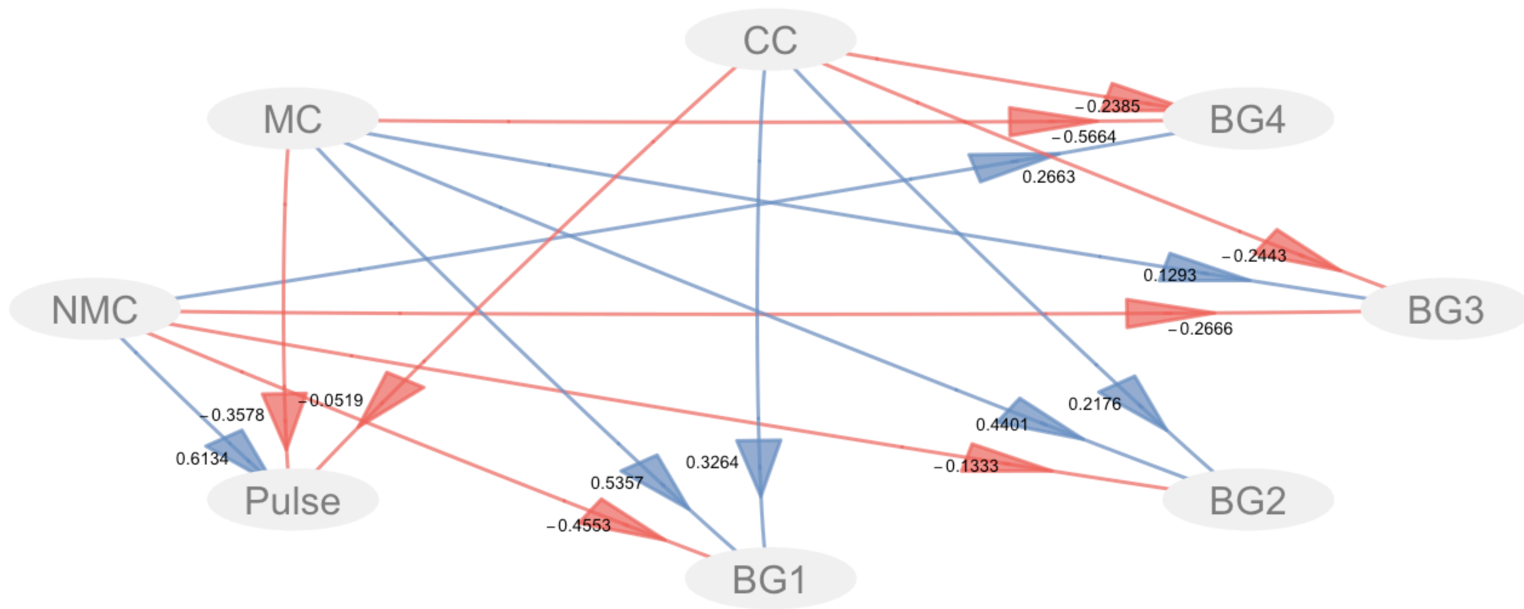

Figure 7-2. Path analysis prediction model. Values are the path coefficient estimates representing the strength and direction of the relations between the response (pulse rate, Behavior Groups 1-4) and the predictors (cortisol: creatinine, metanephrine: creatinine, normetanephrine: creatinine).

APPENDIX A

INTERVENTION HEALTH AND BEHAVIORAL ADVICE BY WEEK

Baseline Exercise Tip: One of the best things you can do for you and your dog's health is to go on daily walks together. Current guidelines for physical activity suggest all adults obtain at least 30 minutes of moderately intense physical activity such as brisk walking, swimming or low-impact aerobics five or more days per week. Taking walks with your dog is one way to improve your health and your dog's! Start by taking your dog on 10-minute walks in the morning and evening on two to three days a week. Over time, gradually increase the number of days and amount of time you walk your dog per week.

Baseline Behavior Tip: If your dog currently pulls on leash, we highly recommend a no-pull harness or head halter along with a comfortable 4-to-6 foot nylon or leather leash be used to manage pulling and aid your dog's walking skills. Walking nicely on leash for many dogs takes time and consistency. Don't worry, you'll get there! Retractable leashes are not recommended for helping your dog learn how to walk politely on leash since the rules (length of the leash) are always changing - plus, they're never recommended in busy urban environments due to the possibility of entanglement and/or injury.

Week One Exercise Tip: The number one reason why people say they aren't physically active is because they don't have enough time to - in their day. One way to avoid this pitfall is to plan a walk with your dog every day. Identify times in your day when you are most likely to commit to a dog walk and write them on your calendar. Maybe that's a 30-minute morning walk or three 10-minute walks spread across the day. Whatever your approach, the key to success is making time each day. You and your dog will both be happier and healthier for doing so!

Week One Behavior Tip: Many dogs will work for food rewards such as cheese or hot dogs, and they're easy to use in training. Wait to feed your dog his breakfast or dinner until after walks, so he/she is eager to train with you on walks. While walking, reward your dog whenever he/she is looking up at you, near your side and the leash is loose. Treating along the pant seam on whatever side you've chosen encourages your dog to be there! If you're worried about using too much food, cut up your treats in small bites and back off your dog's meal if you've had a good training walk!

Week Two Exercise Tip: You may wonder, "Am I really getting enough physical activity by walking my dog?" While out walking, your dog may take breaks to sniff or potty that will make you question whether or not dog walking is good for your health. Rest assured, all physical activity counts! A pedometer can help assess your physical activity and examine how many steps you're taking while walking. Achieving 10,000 steps per day is recommended, and there are roughly 2000 steps in one mile. You can gradually increase your steps over time to insure you (and your dog) are getting enough physical activity.

Week Two Behavior Tip: Does your dog have plenty of energy on walks and isn't tired when you return home? Most dogs have much more energy than their owners! If you've found that even with walking equipment and tasty treats your dog is still pulling on leash, try playing with your dog before a walk to take the edge off. Leash walks provide some energy release, but dogs greatly benefit from high cardio exercise too. So when you're not walking your dog, add in some off-leash time to fulfill his/her exercise needs and leave the leashed walks for exploring the neighborhood with you.

Week Three Exercise Tip: Walking 2 miles per day at a brisk pace will improve your health. Walking briskly means that your breathing and heart rate will feel more rapid, but you shouldn't feel like you're gasping for air. Likewise, you should be lightly sweating. Another "briskness" strategy is to time your route. If you know how far you have walked and how many minutes you've been walking, you can determine your mileage per hour. A brisk 4-mile-per-hour walking pace (about 15 minutes for each mile) is a good recommended speed. While out walking, bring along water for you and your dog. If you notice your dog is panting, stop for a water break.

Week Three Behavior Tip: Walking nicely on leash without pulling can be a complicated skill for dogs to master. From our point of view, we may not realize all the things that go into a nice leashed walk for our dogs: stopping when we stop, waiting to cross the street and maintaining our pace. It's not surprising then that dogs and their owners might need a little assistance to get it right. Having your dog respond to his/her name, making eye contact, sitting at your side - these are just a few skills that could help your walking. For more on AAWL's dog training classes, visit https://aawl.org/pet-training

Week Four Exercise Tip: We encourage you to continue walking on dog-friendly trails and consider walking with other new dog adopters. Many people are not active because they don't have anyone they care share their activity with. Your dog can be a great physical activity companion and a good source of support. You'll probably find that over time your dog recognizes when it's time to go for a walk. His excitement upon seeing your "walking shoes" may be just the motivation you need. Dogs are a great source of positive encouragement and walking together goes a long way in enhancing the bond you two share.

Week 4 Behavior Tip: Once you're seeing improvement in your dog's leash walking, you can start working on fancier skills like politely saying hello to people when passing by. If your dog is overly eager to meet on leash, use some of your dog's obedience skills to smooth the introductions. Provide treats to the stranger and instruct them to ask your dog to sit before being petted. You can also teach your dog to shake or wave to say hello. This way, you set your dog up for success, and he/she learns that behaving politely gets him/her the attention he wants - and you have a more pleasant walk!

APPENDIX B

CONTROL HEALTH AND BEHAVIORAL ADVICE BY WEEK

Baseline: FEEDING - Make sure your dog has access to fresh water at all times. If you plan to change the food the dog is accustomed to eating (Hill's Science Diet), mix the new food with the old food (50/50) for several days, to avoid diarrhea. The dogs at the shelter are fed 2 times per day (morning and evening). If you have other dogs in the house, initially supervise their feedings and/or feed them separately, to make sure there are no 'food guarding' issues. If you have cats in the house, you may want to put cat food in a place where the dog can't get to it (up on a counter), as dogs like to eat cat food too!

Week One: INTRODUCING DOGS - If you have other dog(s) in the household, initially introduce the dogs to each other on neutral ground (if they haven't already met at the shelter). For example, meet at a park, and take walks around the block. When introducing the dogs to each other, have both dogs on leash. Start by walking the dogs past each other a few times (no touching). Follow this by allowing the dogs to sniff each other for 3-5 seconds (on leash) a few times. Gradually lengthen the time of dog-to-dog sniffing/touching from 5 seconds to 10 seconds to 30 seconds. Once both dogs are comfortable with each other on leash, you may want to take them to a fenced in area to allow them to sniff/play off-leash before going into your house. In the first few weeks of owning a new dog (or until you are 100% comfortable), you may want to crate the new dog when you leave the house, to ensure that are no issues between the dogs.

Week Two: EXERCISE - Most dogs need regular exercise, no matter how big or small they are. For high energy dogs, at least two 30+ minute walks per day is recommended. For a lower energy dog, one 30 minute walk per day may suffice. With daily, consistent exercise, you will help your dog become a well-behaved member of the family, and help to avoid destructive behavior. An old saying goes “A tired dog is a good dog”.

Week Three: CRATE TRAINING - Crate training is effective, helps with potty training, and keeps your furry friend out of trouble. Be sure to use a crate that is large enough for the dog to stand up, turn around and lay down comfortably. You don’t want the crate to be too big (as the dog may relieve himself inside it). Make going into the crate a positive experience for the dog by offering a treat in the crate and/or using an excited tone of voice when you are ready to put the dog in the crate. They will learn to love going into the create. It’s like “their home.” Put the dog in the crate when you leave the house and at night. Crate the dog when you are away from the home until you are confident that they dog will not go potty in the house. Be sure to let the dog out of the crate regularly for potty breaks (offer a treat/praise when the dog goes potty outside). Young puppies need to be let out of their crate every 3-4 hours, and adult dog (1 year+) every 6-8+ hours. Leave the dog in the crate when you are away from home. Upon coming home, take the dog outside immediately to potty. Reward with praise and treat when successful. When you are home and the dog is not in the crate, make sure to let your dog outside regularly and reward him with a treat and/or praise when he goes potty outside.

Week Four: INTRODUCING CHILDREN - If you have young children in the household or friends and family with children, supervise interactions with the new dog closely. Upon initial introductions, have your children sit quietly and allow the new dog to approach. Have the children pet the dog underneath the chin (vs. on top of the head).

Young puppies are like children themselves, and can be ‘mouthy’, which is easily correctable with proper training.

APPENDIX C

SURVEY QUESTIONS FOR CONTROL AND INTERVENTION BY WEEK

Baseline Survey: What is your 4-digit ID number?

What is your newly adopted dog's name?

If you have changed your dog's name, what was his/her name while at the shelter?

What is his/her gender?

What is your dog's age (approximately in years)?

What is your dog's breed(s) as listed on the adoption paperwork?

Are you a first time dog owner?

How many other dogs live in your household?

Take a moment to think about the time you've spent walking in the last 7 days before you adopted your dog. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure. During the last 7 days, how many days did you walk for at least 10 minutes at a time?

On one of those days, how much time did you usually spend walking? (If more than 3 hours, please choose 180 minutes)

What is your age?

What is your sex?

What is your race?

What is the highest level of school you've completed?

What is your annual income range?

Please confirm your email address for future correspondence

Weeks One through Four Surveys: What is your 4-digit ID number?

What is your newly adopted dog's name?

Do you still have your dog that you recently adopted from Arizona Animal Welfare League?

If no, what happened?

During the past 7 days, how many days did you walk your dog for at least 10 minutes on a single outing?

On a day that you walk your dog, how many minutes do you usually walk on that outing? (If more than 3 hours, please choose 180 minutes)

Weeks One and Four Additional Dog Obligation, Walking and Behavior Survey Questions: I feel an obligation to walk my dog regularly

I enjoy walking my dog

I will walk my dog even though I am feeling sad or highly stressed

I will walk my dog even when the weather is bad

I will set aside time for regularly walking my dog

I do/did not have good control over my dog; my dog does/did not listen to me

My dog does/did not behave well when on leash (i.e. pulls on leash)

My dog walks/walked too fast for me

My dog is/was too energetic or "hyper"

APPENDIX D

CO-AUTHOR PERMISSION

Co-authors, Alexandra Protopopova, Steven P. Hooker, Cheryl Der Ananian, and Clive D. L. Wynne, have granted their permission for the inclusion of the article, Impacts of Encouraging Owners to Walk Their Dogs on the Return of Newly Adopted Dogs to an Animal Shelter, in this dissertation document.