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STRESS IN DRUG DETECTION DOGS AND THEIR HANDLERS

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ABSTRACT

Working dogs, such as drug detection dogs, contribute in many ways to human health, happiness and safety. Research has shown that dogs look to humans for cues on how to behave; this is what allows us to train dogs for specific purposes like drug detection. Studies have shown that human behavior and human hormonal changes affect levels of stress hormones in dogs, especially working dogs. Certification testing is a stressor to disaster dog handlers. For this study, salivary cortisol and heart rate data were collected from 15 dogs in the Pennsylvania Department of Corrections Drug Interdiction Unit before and after the handlers' yearly certification test, and on a control day with an identical procedure. Heart rate, blood pressure, and salivary cortisol were collected from their handlers and each filled out a State-Trait Anxiety Inventory on both days. Human saliva was sent to a local laboratory for analysis while Salimetrics- Cortisol Enzyme Immunoassay Kits were used to analyze the dogs' saliva. SPSS statistical analysis software was used to find correlations between variables and compare means. The expected result was that heart rate, salivary cortisol, and/or the Anxiety Inventory would reveal that the yearly certification test was a stressor for canine handlers, and that heart rate and/or hormonal data in the dogs would reflect a similar trend. However, according to the Anxiety Inventory, handlers were not significantly more stressed on the test day. Human and dog cortisol were not found to be correlated. No correlation was found between handler blood pressure and stress indicators in the dogs, but a significant positive correlation was found between handler heart rate on test day and canine cortisol after the test. This may indicate that the dogs were able to sense and respond to handlers' heart rates more effectively than to other behavioral or physiological markers.

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INTRODUCTION

Dogs have been used for hunting, warfare, and camaraderie throughout the world for thousands of years. Besides simple companionship and therapy for people with medical or emotional problems, dogs are now trained for specific uses like guarding homes and properties, searching for people, animals, and drugs, providing assistance for the blind and epileptics, and for many other purposes. The dog/owner relationship has received much attention in recent decades, but more recently, interest in working dog welfare, behavior, and performance maximization has resulted in several studies being performed. This research has led to improved welfare and training methods for these dogs in many instances.

Certification as a Stressor

A previous study found certification testing to be a stressor to disaster dog handlers and that this stress was associated with stress indicators in the dogs (Lit et al., 2010). This study examined handler salivary cortisol levels, handlers' subjective assessments of stress in themselves and the dogs, and canine posttest heart rate and temperature on the day of certification testing.

Post-test, cortisol was shown to be higher in the handlers than in control individuals, indicating that certification was indeed a stressor to the handlers (Lit et al., 2010). Interestingly, handlers who listed their primary occupation as “firefighter”, the most stressful of the listed occupations, had lower post-test cortisol concentrations than other participants. These results can be interpreted to indicate that occupation influences the relationship between stress and performance.

Handler cortisol after the test was positively correlated with dog pulse and temperature after the test as well as the subjective assessment of stress in both the dogs and the handlers after the test (Lit et al., 2010). This confirmed that handler stress caused physiological indicators of stress in dogs. These results provide a framework for our hypothesis that some interaction will take place between handler and dog stress indicators during drug detection certification testing.

The Dog/Handler Relationship

As a result of thousands of years of domestication, dogs are able to understand and respond to human social cues with better accuracy than all other animals, including apes (Haverbeke et al. 2010). Working dogs and their handlers are, at their core, social beings; this is what allows humans to form such effective partnerships with dogs but it also means that dogs are very sensitive to the dynamics of the relationships they share with their handlers. Handlers’ training methods and treatment of their canine partners are inextricably linked with the performance of the team.

A new human familiarization and training program was provided to some Belgian military working dogs that involved regular, positive dog/handler interaction while others were handled with traditional methods (Haverbeke et al. 2010). The dogs undergoing the experimental treatment performed better at protection and obedience exercises than the control dogs trained with the traditional methods of the Belgian military. Control dogs spent less time training and had very little human socialization while the experimental dogs received these. Also, handlers of the experimental group were trained to use positive reinforcement while the control group handlers used their usual proportion of positive to aversive training methods. Their traditional system uses aversive training methods, or punishments, as an important part of the training process. These results clearly showed that positive interaction with handlers and positive reinforcement training as well as more frequent and regular training sessions worked more quickly than punishment and infrequent training sessions to enhance the dogs' natural ability to understand and obey handler signals.

In Belgium, a study included 303 military dog handlers who completed a survey about their relationships with their dogs (Lefebvre et al., 2007). Results showed that dogs that played with their handlers outside of work hours, and especially those dogs living with handlers and their families, showed superior obedience over those that did not interact with handlers after hours. These dogs also showed fewer instances of behaviors that indicate welfare issues. Meanwhile, no association was found between handler experience and canine obedience.

An element of the dog/human relationship unique to police dog handlers is the conflict of seeing these dogs simultaneously as weapons and as partners, as pointed out by Sanders (2006). He states that there exists a "constant paradox" in any animal/human relationship as we are conditioned to see animals as both potentially useful objects and conscious beings. This relationship is nowhere more complex than between police dogs and handlers, whose lives may depend on the dogs. Sanders observed training exercises of police dogs and handlers for two years to investigate this relationship. He notes that in standard training literature and rhetoric, the dogs are referred to sometimes as machinelike creatures that respond to operant conditioning techniques to produce reliable results, and in other instances compared with children in that they are each unique, emotional, and unpredictable (Eden 1993, Lasher 1998, Rapp 1979, Sanders 2000, Sanders 2006, Wieder 1980). He states that police dog handlers and trainers in general realize that for the dog/handler partnership potential to be fully realized, operant conditioning techniques must be used but mutual trust, loyalty, understanding, and affection must also be achieved.

Human Behavior Affecting Canine Hormone Levels

Hormones are reliable indicators of physiological states within the bodies of people and dogs. While hormone levels reliably indicate the physiological states of both dogs and in people, previous studies have found varied results on the subject of human influence on canine hormonal systems.

Jones and Josephs (2006) showed that handler hormonal changes affected cortisol levels in agility dogs. Specifically, high levels of testosterone in male handlers before a trial meant higher cortisol levels in dogs after the trial if the team was unsuccessful. Also, handlers whose testosterone dropped the most after losing had dogs with the greatest spikes in cortisol. The handlers' behavior towards the dogs after competition, either punitive or affiliative, appeared to be the link between the emotions of the two. Dogs that were punished because of an unsuccessful trial had significantlyhigher cortisol levels after the trial than before it. Interestingly, no significant hormonal correlation between dogs and handlers was found for successful teams.

Another study investigated dog/handler teams in animal-assisted therapy (Haubenhofer et al., 2007). Salivary cortisol data showed that both the handlers and the dogs were more stressed out on therapy days than on control days. Handlers were most stressed by sessions of long duration, while the dogs were most stressed when sessions occurred most frequently throughout the week. This may indicate increased stress levels, or at least elevated cortisol levels, in various working dogs that perform most frequently.

Dreschel and Granger (2005) exposed phobic dogs to simulated thunderstorms and measured their behavioral and salivary cortisol changes in response to the stimulus and owner behavior. Cortisol levels in the dogs spiked in response to the storm and had not returned to baseline values 40 minutes later. However, neither the strength of the dog/owner relationship nor the behavior of the owner during the storm affected the behavior or cortisol levels of the dogs. Overall, the salivary cortisol concentrations of the owners did not change in response to the dogs' stress. This study seemed to indicate a lack of hormonal interaction between dogs and humans in a particular situation where the dog is the one primarily facing stress.

The cortisol responses of police and border patrol dogs after three minute play sessions with their handlers were investigated by Horváth and others (2008). Notably, the police dogs showed significantly higher levels of salivary cortisol than the border patrol dogs after these sessions. Behavior analysis revealed that the police officers chose to play with their dogs in an authoritative manner, providing reprimands and discipline. The border patrol officers, given the same instructions, chose to play with their dogs using affectionate behavior.

Stress Responses in Working Dogs

The subject of stress in working dogs has been evaluated in a limited number of studies. Researchers often have difficulty gaining access to police and military personnel to conduct interviews and dogs to collect physiological data because of concerns that negative publicity may result if individuals outside the law enforcement community are allowed intimate access (Sanders 2006). Nonetheless, some studies on this subject have been performed.

Haverbeke and others (2007) sent a survey to military dog handlers in Belgium who revealed that harsh training methods are used to train these dogs. These punishments included tugging on the leash, hanging the dog by its collar, verbal scolding, and hitting the dog. Teams were then evaluated while performing obedience and protection work. Results showed that dogs that received more of the harsh reprimands performed at lower levels than dogs punished less often. On the second of two separate instances of evaluation the handlers exhibited more punitive behavior and fewer rewards, resulting in lower posturing in the dogs, which is one indication of welfare issues. The authors concluded that the welfare of these dogs may be compromised and that more positive training methods, increased frequency of training sessions, and an improved dog/handler relationship may improve team performance. The dogs in the current study are regularly trained using primarily positive reinforcement; literature suggests that these methods are the most sound for animal welfare and performance.

Haverbeke and others (2008) examined the behavioral and cortisol responses of military working dogs in Belgium to various environmental challenges on two separate instances. Researchers found that these dogs showed fewer stereotypic behaviors, which indicate boredom and/or stress, during these challenges than when no stimuli were present. They also had higher postures during the second challenge. Cortisol levels also returned to baseline more quickly after the second challenge. Together these results indicated that while this group of working dogs may have some welfare issues, their ability to adapt to new stimuli shows they are not chronically stressed.

Pastore and others (2011) examined the correlation between hormonal and behavioral indicators of stress in agility dogs. Stress-related behaviors were observed in these dogs at the time of competition. Salivary cortisol was found to be slightly elevated after the trial, but was not significantly correlated with behavioral stress indicators in individual dogs. This study highlights the importance of studying behavioral as well as physiological indicators of stress to obtain a fuller picture of the emotional state of working dogs.

Canine Methods of Information Acquisition

The intrinsic conflict in trainers' and handlers' view of working dogs simultaneously as reliable automatons and as individuals with unique needs and talents has been previously discussed. Individual canine factors as well as the nature of the dog/handler relationship are both important to ultimate canine performance (Sanders 2006). Several studies have examined the idea of canine "personalities" as they affect the behavior of companion and working canines, while others have explored the results of particular obedience training methods on working dog performance.

The idea that dogs learn by operant conditioning is generally accepted, but one study has explored further the way that dogs acquire new information. In agility dogs, a significant positive correlation was found between time spent in deliberate practice and measured performance. This method for acquiring expertise was found to be similar to one used in humans, showing that dogs learn and perfect new skills in the same way that humans do; the author claims that this study forms the basis for the use of dogs as human models in experiments that examine the interaction of natural talent with training to acquire skills (Helton 2006).

Dogs not only learn in ways similar to humans, they also actively seek information from humans. One study allowed dogs to choose between an informant (a person actively directing the dog to a location) and a non-informant to help them find food (McMahon et al., 2010). Even when the informant did not accurately lead to food, the dogs continued to seek the assistance of the informant. Dogs' ability to simultaneously work independently and look to humans for direction is invaluable to the success of team jobs like searching for drugs.

One study administered online surveys to search dog handlers to determine what training methods were used to train the most successful dogs (Alexander et al., 2011). Results showed that the majority of nationally certified dogs were trained using positive reinforcement. Unsurprisingly, dogs that trained for the longest total weekly time were more likely to have achieved national certification. Most of the successful trainers began working with the dogs before six months of age using positive reinforcement, but they reported using more punishment aids as the dogs aged. This illustrates the ubiquity of positive training as the primary method of training for military dogs in the United States.

Training methods were examined in search and rescue dogs by Lit and Crawford in 2006 to determine if training dogs to search for both live humans and cadavers in disaster situations leads to decreased performance. Dogs trained to detect both survivors and cadavers performed with the same success as those trained to search only for survivors when only live human scent was present. However, when both scents were present, the dually trained dogs performed less efficiently. The dogs in the current study are trained to detect several illicit drugs, but only one command and one type of alert are taught; other dogs are trained to detect non-illegal drugs such as tobacco so that handlers know whether a search is warranted depending on whose possessions or body is being searched. This may also lead to less confusion among these dogs than disaster search dogs trained to detect multiple scents.

Canine Personalities

Increasing numbers of studies have been done on the topic of canine personalities. One such study pointed out that canine personalities do exist but are difficult to define because they have different dimensions than human personalities (Ley et al., 2008). Researchers compiled adjectives used by owners of companion dogs who filled out surveys about their dogs. Five major categories of canine personality emerged; two of these, extraversion and neuroticism, were similar to traits found in other animal species. The other three, self-assuredness/motivation, training focus, and amicability, have never been uncovered in other species besides *Canis familiaris* in the course of similar personality factor analysis studies. The authors proposed that these traits became pronounced in the canine population because of many generations of selective pressure in the form of intentional breeding and subtle favoritism.

Sinn and others examined the reliability of trait/personality testing in working dogs in 2010. Dogs were rated in four personality categories: object focus, sharpness, human focus, and search focus. Dogs were re-tested multiple times for performance in these categories and short-term but not long-term re-test reliability was noted for these categories and for most individual behaviors. Canine personality factors are an important component of canine performance and potentially may influence hormone levels.

Svartberg (2002) found a slightly different set of personality factors in working dogs and one overarching factor that seemed to predict performance success. The five traits were playfulness, curiosity/fearlessness, tendency to give chase, sociability, and aggressiveness. The overall predictive factor of shyness/boldness was identified and the highest performing dogs were classified as bold. Further study into the issue of canine personality effects on working dog success may help in the selection of dogs to enter into service. Particular breeds are chosen for different branches of work not only for physical traits, but mental capabilities and behavioral tendencies.

Validity of Salivary Cortisol Analysis

Cortisol is a stress hormone from the adrenal glands that is found circulating in the blood and saliva of humans, dogs and other animals. Its release is prompted by activation of the HPA (Hypothalamic-Pituitary-Adrenal) axis. The hypothalamus creates corticotropin-releasing hormone (CRH) in response to stress in dogs and people and as a result of the sleep/wake cycle in people. CRH stimulates the anterior lobe of the pituitary to produce adrenocorticotropic hormone (ACTH) which then causes the adrenal cortices to create cortisol. Cortisol then stimulates the adrenal medulla to produce epinephrine and norepinephrine which help the body to deal with stressful situations. As a result, the body shifts its energy usage towards fighting and/or escaping stressors and away from other processes such as immune function.

Cortisol is well known as a stress indicator and though not every stressor elicits a response from the HPA, this response is easy to measure so its measurement often plays an integral role in studies that endeavor to determine stress levels in people or animals. Other physiological indicators of stress, such as heart rate and blood pressure, are reliable indicators of acute stress that result from activation of the sympathetic nervous system (Rushen et al., 2008).

Salivary cortisol is accurately representative of blood cortisol levels because it diffuses into saliva through glands that maintain the concentration of cortisol in saliva similar to blood cortisol concentration independently of the amount of overall saliva production. Analysis of saliva for levels of steroid hormones is a popular method because it is relatively non-invasive and simple to perform (Lewis 2006).

Issues may arise with collection methods, steroid stability, and reference ranges. Some collection materials may react with cortisol and any collection medium must be stored carefully until analysis is performed to prevent degradation of cortisol. Dreschel and Granger (2009) described method for saliva collection from dogs. They found unflavored hydrocellulose swabs to be the most efficient material and least likely to interfere with results of hormonal analysis. They noted that consistency in collection procedures is important and that there is much individual variation between dogs in cortisol levels. This makes it difficult to establish a normal physiological range for canine salivary cortisol.

Certain factors are known to cause sampling variation in salivary cortisol. One study found that in simultaneously collected samples salivary and plasma cortisol in individual dogs were correlated at a level of 0.98. The time of day and collection location did not affect salivary cortisol concentration in these dogs, indicating that dogs do not possess a 24-hour cycle of cortisol concentration changes as humans do (Wenger-Riggenbach et al., 2010). A similar study determined that brief (four minute) restraint did not elevate cortisol levels in dogs. Salivary cortisol samples were also taken and analyzed from dogs several times a week, at the same times each day, over a four week period. Most variation present was due to individual differences between dogs and between collection days rather than the time of day (Kobelt et al., 2003).

Olson (2002) proposed that interdisciplinary cooperation is essential to maximize the health and performance of all working dogs. Olson refers to the disciplines encompassed within the National Academies of Practice: dentistry, medicine, nursing, optometry, osteopathic medicine, pharmacy, podiatric medicine, psychology, social work, and veterinary medicine. She points to the success of guide dog training schools that comprise professionals in all of these disciplines working to ensure the physical and emotional health of the canine and human members of each pair. The research summarized here includes information about human and canine biology and physiology, psychology, and ethnography; each of these elements must be considered both for the purposes of this study and for the overall goal of enhancing the working dog/handler relationship to maximize the performance of the team.

Hypotheses

Past studies have evaluated stress and/or performance in agility dogs, search and rescue dogs, and police and military working dogs using physiological parameters as well as behavior analysis of these dogs and their handlers. The objective here was to evaluate several physiological markers of stress in both drug detection dogs and their handlers. The handlers' self-reported anxiety was also recorded using a questionnaire. Data were collected before and after the dog/handler teams' annual certification tests and before and after an identical procedure on a control day. The objectives of this study were to determine if heart rate, salivary cortisol, and/or an anxiety inventory reflect stress for handlers and whether in turn this causes stress in their dogs. Canine physiological or hormonal changes are expected to depend on handler actions or hormonal patterns. Results have the potential to improve canine welfare and overall performance in working dog/handler teams in the future.

MATERIALS AND METHODS

All data was collected from 15 dog and handler teams at a Pennsylvania prison warehouse on October 25th and 26th 2011. On each of these two days, the teams performed planned searches for synthetic drugs. The teams' annual certification testing took place on October 25th and October 26th was considered a training or practice day upon which the teams' certification status did not depend.

Subjects

Fifteen dogs were included in the analysis of this study. Seven of these dogs were female Belgian Malinois, six were male Labrador Retrievers, one was a female Labrador Retriever, and one was a male German Shepherd Dog. Canine age ranged from 2.5 years to nine years. All dogs were spayed or neutered. Fourteen of the fifteen handlers were male and all were between the ages of 33 and 56. The approved IACUC protocol number for this study is 37826. The IRB protocol number for the study is 37388 and the Biosafety Protocol number is 37940.

Procedure

Identical procedures were followed on the test and control days. Each day, handlers were asked to complete an anxiety questionnaire upon arrival at the test location. Saliva samples were collected from each handler and dog before and 20 minutes after each drug search was performed. Pulse rates were collected from each dog and handler before and immediately after the search and blood pressures were collected from handlers before and after the search. Each team performed several short searches around boxes in a warehouse (**Figure 1** and **Figure 2**) until the dogs alerted on the scent of drugs in a particular location (**Figure 3),** after which the dogs were rewarded for their searches with play (**Figure 4)**.

Figure 1 A dog is hot on the trail

Source: Nancy Dreschel

Figure 2 A handler directs a dog in the search for artificial drugs

Source: Nancy Dreschel

Figure 3 A dog provides an "alert" **Figure 4** A dog is rewarded with play

Source: Nancy Dreschel

Source: Nancy Dreschel

State-Trait Anxiety Inventory

The State-Trait Anxiety Inventory for Adults, developed by Charles D. Spielberger in 1977, was used to help determine stress levels in the handlers on each day of the study. The first page of this inventory asks participants about their emotions at the current moment (state) and the second page asks about how the participant feels in general (trait). Each page was scored using a scoring guide to arrive at a number describing the participant's overall emotional state at the moment and one to describe the participant's emotions in general.

Success Ratings

Dogs and handlers were rated on their success each day by their evaluators using the scale normally used for certification testing. Dogs were awarded a score between one and ten while handlers received ratings on a scale of one to three. Criteria used to critique the dogs included search intent, the speed of the "alert" (notification to handler that the simulated drugs had been located), interest in the artificial drugs, and the enthusiasm of the response. Handler criteria included proper leash control, use of correct search sequence, detection of the dog's alert, and provision of the appropriate reward to the dog.

Salivary Analysis

Cortisol, a hormone that is released in response to stress, was evaluated in the saliva of both the handlers and the dogs before and after the test and control procedures. Each dog was used as its own control for levels of salivary cortisol because there is much individual variation in normal cortisol levels between dogs (Dreschel and Granger 2009). Human saliva was collected using short straws and small plastic tubes; the handlers collected these samples themselves. Canine saliva was obtained by a veterinarian using hydrocellulose swabs placed into the dogs' mouths until they began chewing and salivating. All saliva samples were frozen on dry ice immediately after collection and stored at -20 °C until processing.

Human saliva was sent to Salimetrics in State College, Pennsylvania to be assayed for testosterone and cortisol. Canine saliva was assayed for saliva using Salimetrics High Sensitivity Salivary Cortisol Enzyme Immunoassay kits. The test principle involves a microtitre plate coated with monoclonal antibodies to cortisol. Solutions with standard cortisol amounts were mixed with solutions containing cortisol conjugated to horseradish peroxidase; these two types of cortisol molecules competed for binding sites on the monoclonal antibodies. A standard curve was eventually prepared to create a comparison for cortisol concentrations in the saliva samples. An identical laboratory procedure was used with the saliva samples containing unknown amounts of cortisol. Twenty five microliters of each sample was used. Samples were not diluted but the conjugate was diluted before addition to each well with a solution containing a phosphate buffer, a pH indicator, and a preservative. The sensitivity of this assay was <0.003 µg/dl. The inter-assay coefficient of variation was 1.396 and the intra-assay coefficient of variation was 10.73. The plates were then incubated before the unbound cortisol was washed away. Tetramethylbenzidine (TMB) was then added to each well to react with the remaining cortisol-peroxidase conjugate, producing a blue color in each well. Sulfuric acid was added to each well to stop the reaction and the resulting yellow color intensity in each well was then read at 450 nm by a standard plate reader. A highly intense yellow color indicated a high concentration of cortisol peroxidase bound to the monoclonal antibodies, signifying a low concentration of cortisol in the sample of saliva. Thus, the intensity of the resulting color was inversely proportional to the amount of cortisol in the unknown sample.

Two plates were used to accommodate the number of samples to be tested. All but three of the saliva samples were of a sufficient volume to be assayed in duplicate, and values were averaged for those samples assayed in duplicate. The standard curves generated by each plate (**Figures 5 and 6**), along with the absorbance values used to generate the curves (**Tables 1 and 2**) are listed below. Note that the absorbance values for the cortisol standards were so similar on each plate that the resulting curves produced very similar equations. This unusual result showed that the standard curves were precise as they were very similar to each other. The high R-values also attest to the reliability of the standard curves.

Table 1 Plate 1 cortisol standards and absorbences

Std	absorb
3	0.06
1	0.15
0.333	0.36
0.111	0.65
0.037	0.84
0.012	0.95

Figure 5 Plate 1 standards plotted to make a standard curve

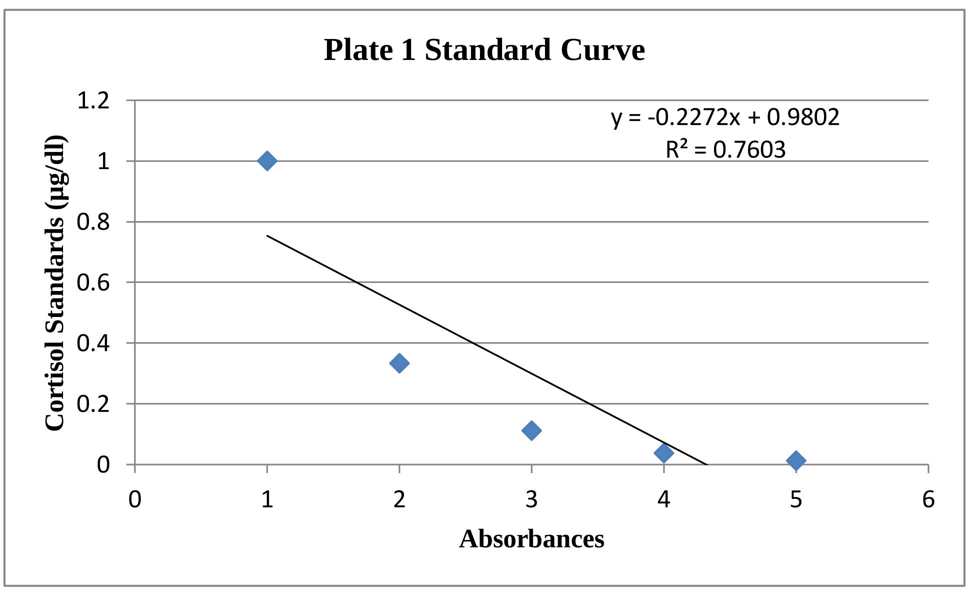
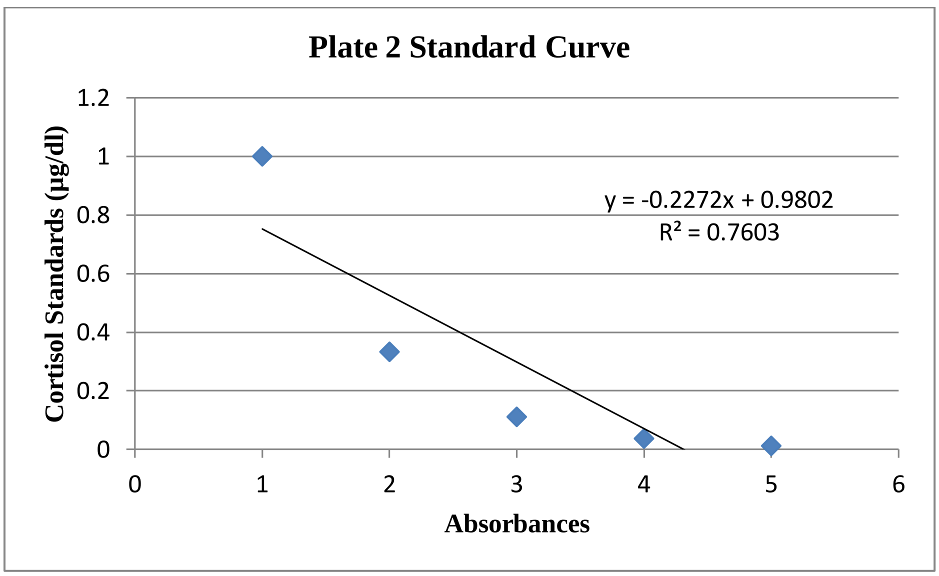


Table 2 Plate 2 cortisol standards and absorbences

std	absorb
3	0.06
1	0.16
0.333	0.36
0.111	0.67
0.037	0.86
0.012	0.95

Figure 6 Plate 2 standards plotted to make a standard curve



Data Analysis

Excel software (Microsoft, 2007) was used to calculate and create the standard curves in the analysis of cortisol in canine saliva. SPSS statistical analysis software (IBM, Version 20) was used to analyze trends and correlations in data and their significance. Descriptive statistics were run to find correlations between variables and paired samples t-tests were run to discover if differences were significant.

3

RESULTS

Each team was successfully certified after completion of testing. Both the test and control procedures were divided into several short searches, after which the dogs were rewarded and handlers were given feedback on how to improve performance. The dogs were rewarded with play frequently throughout the certification test and the control day procedure. The dogs were rewarded both during previous training and during study procedures by play consisting of tugging on a small towel with their handlers.

Handlers were not significantly more stressed on the test day than on the control day according to STAI data. Human and canine cortisol values were only correlated after the control day exercise. The heart rates of the dogs were not different before vs. after the test, nor were they different between the days. A significant positive correlation (0.722, $p<0.002$) existed between the handler heart rate before the test and canine cortisol after the search procedure on the test day. Results of further analysis of factors that may interact to contribute to stress in the handlers and dogs are described below.

State-Trait Anxiety Inventory

STAI results indicated that handlers were not more stressed on test day than control day; the scores for state anxiety on these two days were correlated at a level of 0.685 ($p=0.005$). According to a paired samples t-test, the average difference in score was 1.47, but these results were not significant ($p=0.452$, $SD=7.34$, $df=14$).

As expected, the correlation between the trait results on the two days was high at 0.925 ($p<0.001$). The average difference in trait score between the two days was small but significant at 2.14 ($SD=3.40$, $p=0.034$). Interestingly, average anxiety index values for all the handlers on each day, for both state and trait, were lower than the average anxiety index score for working men in the general population in the same age range as the dog handlers (**Table 3)**. The means ranged from 28.4 to 31.4 while the mean value for the general population is 35.7 (Spielberger 1977).

Table 3 All STAI score means

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
STAI-state test day	15	20	51	28.40	9.876
STAI- trait test day	15	21	52	31.40	9.249
STAI-trait control day	14	20	47	27.79	8.816
STAI- state control day	15	20	47	26.93	8.198
Valid N (listwise)	14				

No correlation was found between handler emotional state on control day and canine heart rate after the control procedure.

Physiological Data

Data on the dogs' and handlers' heart rates and the handlers' blood pressure proved useful in the course of this study. The dogs perform tasks similar to the certification testing procedure frequently, so they were likely not unusually physically stressed on test day by the work performed. The dogs' heart rates did not vary much due to the search activity nor did it vary between the days; no significant correlations ($p \leq 0.05$) were found involving canine heart rate and either canine or handler data.

Handler heart rates before the control procedure were higher than before the certification test. A paired samples t-test showed a mean difference of 7.80 beats/min ($SD=12.9$, $p=0.034$) between handler heart rate before the test procedure and handler heart rate before the control procedure (**Table 4**). A high standard deviation may have resulted from different stress and fitness rates between the handlers, perhaps due to experience level and/or age.

Table 4 Difference in heart rates of individual handlers on control and test days

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Handler HRcont1 - Handler HR test1	7.8000	12.8797	3.3255	.6675	14.9325	2.346	14	.034

No correlations were found between handler blood pressure and either dog heart rate or cortisol levels.

Salivary Cortisol Concentrations

Salivary cortisol results provided the most interesting and unexpected results upon data analysis. Raw values are reported but transforming statistics (absolute value of natural logarithm of true value) were successfully run on the data to adjust for heterogeneity of error variance. Human and canine cortisol were not correlated at any time (**Figure 7**). They were correlated after the control exercise but not significantly (0.507, p=.064, r=0.257) (**Figure 8)**.

Figure 7 Dot plot of relationship between handler and dog salivary cortisol after the test day procedure

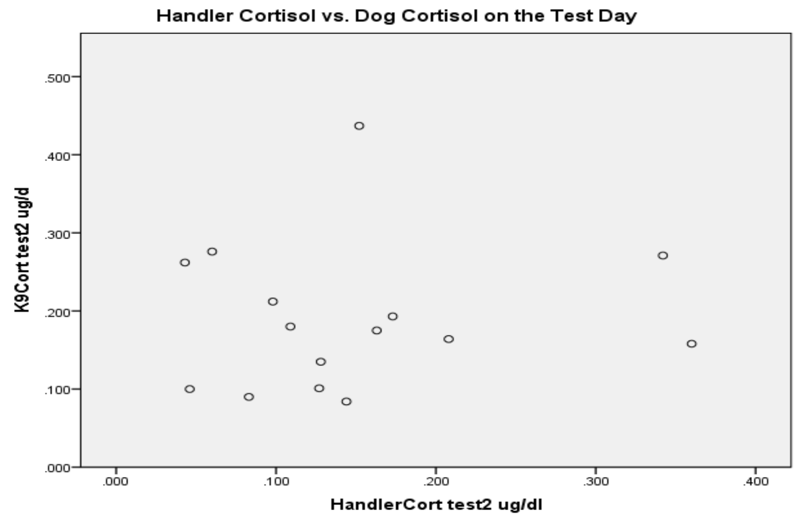
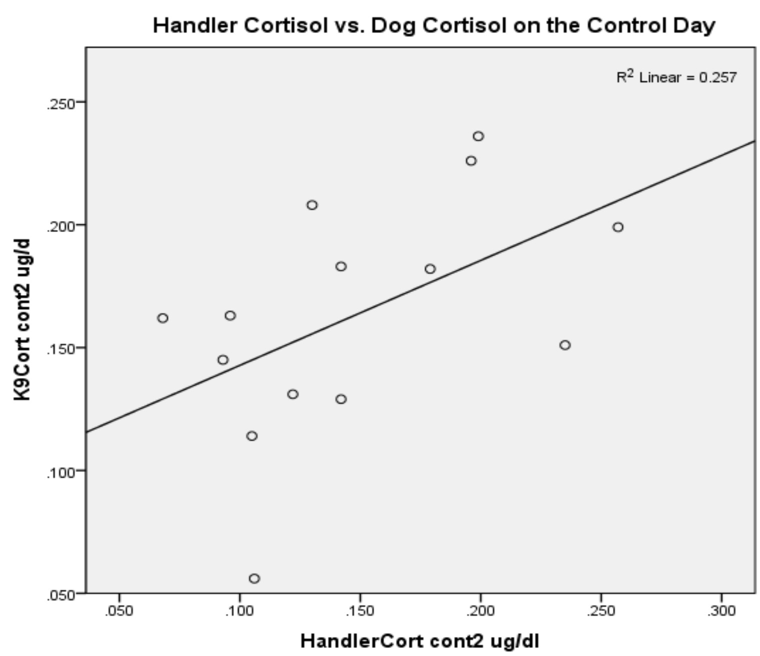
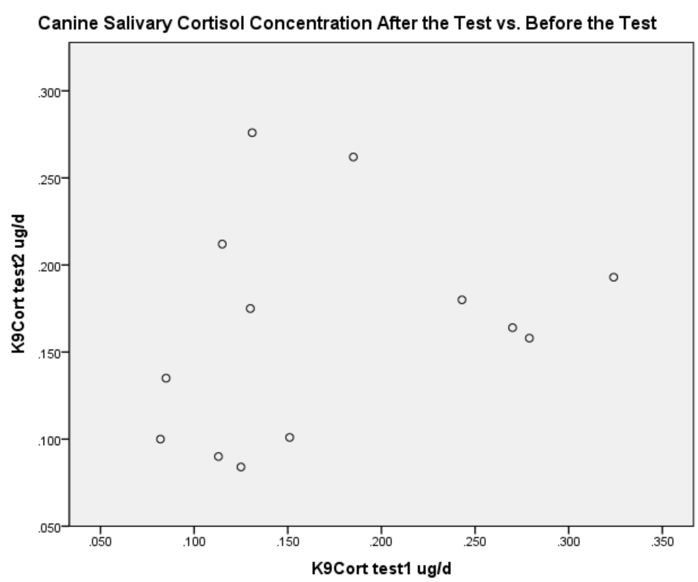


Figure 8 Dot plot of relationship between handler and dog salivary cortisol after control day procedure



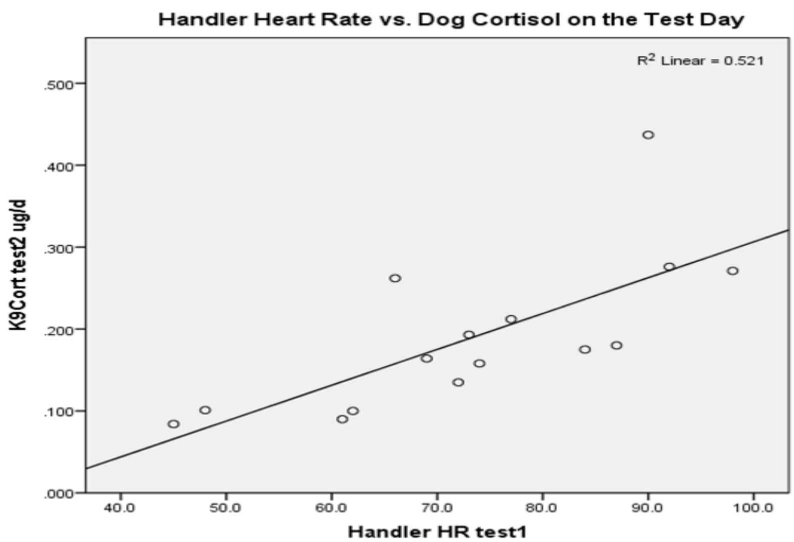
A non-significant positive correlation (0.268, p=0.376) was found between canine cortisol levels before and after the test procedure but not between cortisol levels at all times (**Figure 9**). A paired samples t-test revealed no significant difference between canine cortisol before and after the test (p=0.75).

Figure 9 Canine cortisol levels did not significantly change after the test had been performed vs. before



A positive correlation was found between handler heart rate before/after the test and canine cortisol after the test (**Figure 10**). The r^2 value was 0.722 for the heart rate before the test (p=0.002) and 0.497 after the test (p=0.059).

Figure 10 Relationship between canine salivary cortisol and handler heart rate on test day



Success ratings

Very little variation was found between handler scores because the scale was quite small, but canine performance success was analyzed against handler heart rate and cortisol. No correlations were found. However, positive relationships were found between the dogs' test scores and their heart rates before the test (r^2=0.551, p=0.033) (**Figure 11**), and dogs' control day scores and their heart rates after the search (r^2=0.711, p=0.003) (**Figure 12**). Canine performance was quite consistent between the two days with a correlation of r^2=0.799 (p=0.000). Individual canine performances between the two days were not significantly different; according to a paired samples t-test the average score difference was only r^2=0.2 (p=0.111) (**Table 5**).

Table 5 Canine performance was consistent between the two days

Paired Samples Test

		Paired Differences				t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper		
Pair 1	K9 score test - K9 score control	-.2000	.4551	.1175	-.4520	.0520	-1.702	14	.111

Figure 11 Relationship between canine test score and heart rate before the test

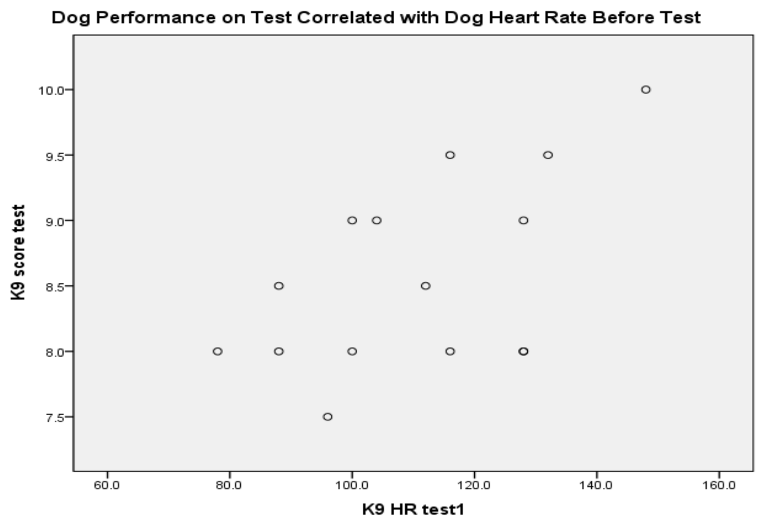
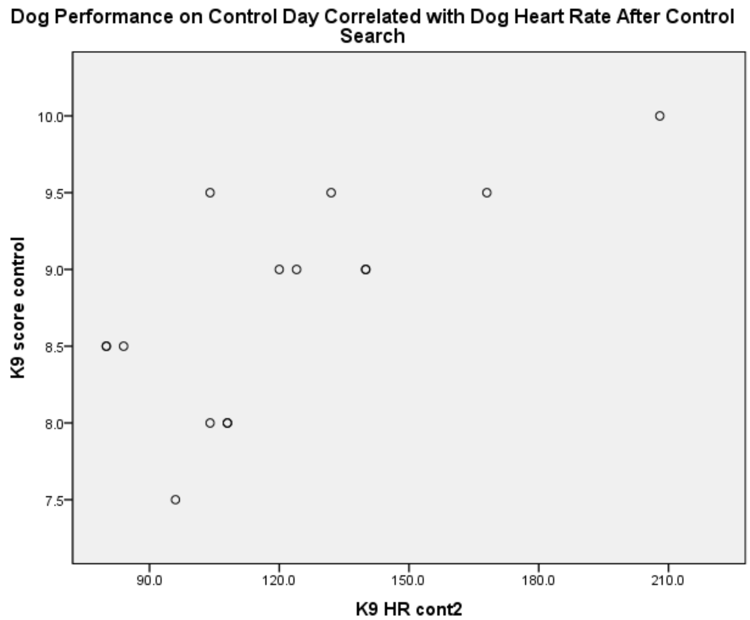


Figure 12 Relationship between canine test score and heart rate after control day search



Handler experience

The effects of handler experience were investigated in the course of data analysis. Results showed no correlation between years the handler has spent in the Drug Interdiction Unit and the results of the anxiety inventory. However, negative correlations between the number of years spent in the unit and handler cortisol after both the control (-0.677, p=0.006) and the test (-0.518, p=0.048) procedures were noted (**Figures 13** and **Figure 14**).

Figure 13 Relationship between handler experience and handler salivary cortisol after the control day search

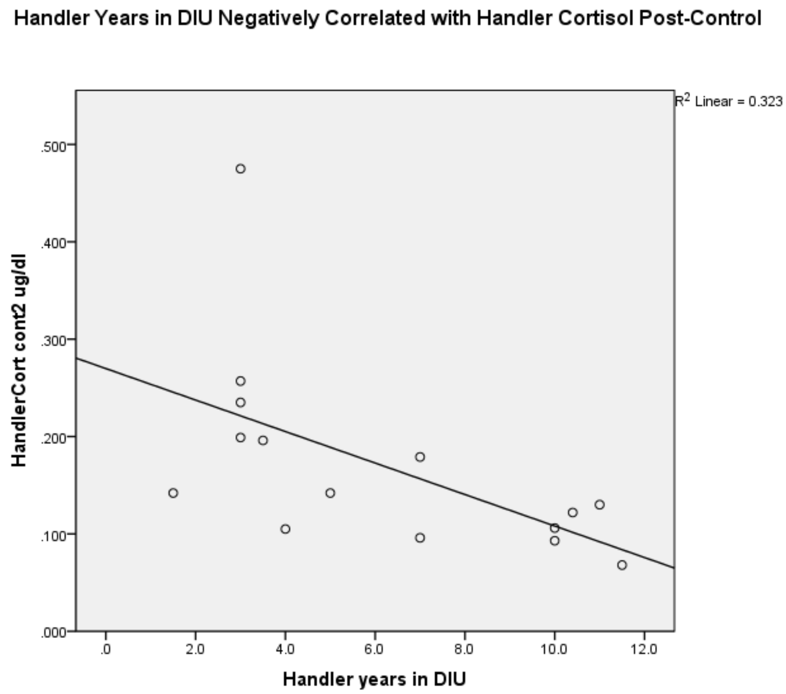
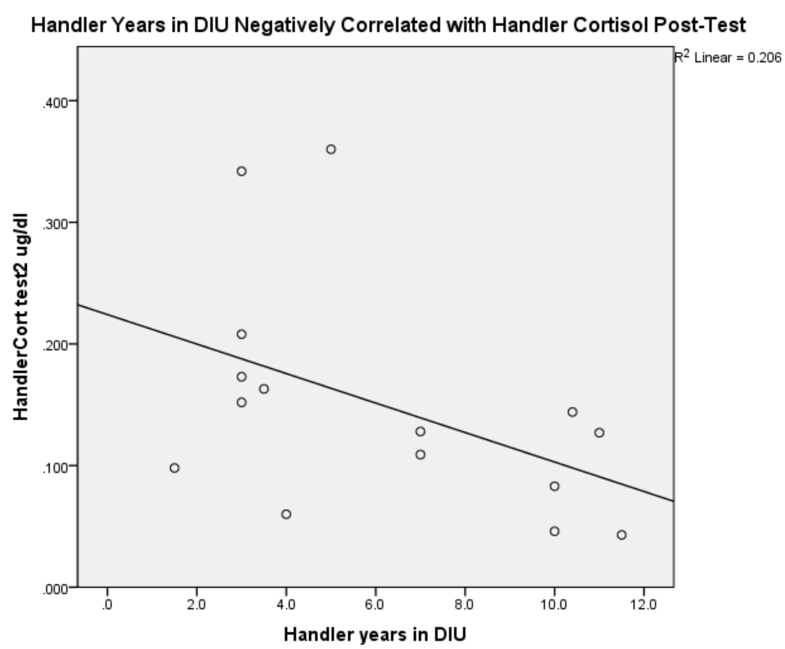


Figure 14 Relationship between handler experience and handler salivary cortisol after the certification day search



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4

DISCUSSION

Results from this study did not reveal handlers to be more stressed on the test day than the control day. Human and canine salivary cortisol concentrations were not correlated on the test day. However, the dogs experienced elevated cortisol levels simultaneous to the handlers' elevated heart rates; it is unclear how the dogs were able to sense the heart rate increase.

State-Trait Anxiety Inventory

STAI scores were not higher on the test day than on the control day. These findings differ from those of Lit (2010), where certification served as a stressor to disaster search dog handlers. This may reflect the fact that the evaluator/supervisor of each handler was present and provided immediate verbal performance feedback during both the test and control day searches, so that the handlers were not less stressed on the control day.

The correlation between each handler's trait score on each of the two days was highly positive, as expected, because the trait portion is intended to reflect the handlers' reported emotional state in general, while the state portion reflects the handlers' feelings at the moment. The relatively low average state and trait stress values obtained each day were striking because one might expect that prison guards have a daily occupational stress level higher than that of civilians. However, these relatively low values may suggest that these officers are accustomed to stressful situations and so they view daily challenges and certification testing as less stressful.

Physiological Data

Canine heart rate results showed little change and no significant correlations with any other data, including canine salivary cortisol. The dogs' heart rates were likely to be elevated to the post-exercise level before the test and control day searches because the dogs behaved in an excited manner and seemed to know that they were preparing to perform a search after being retrieved from their handlers' cars. Also, the heart rates may have been steady because the dogs are very accustomed to the action of searching and the physical activity that it entails. The lack of variability in canine heart rates provides evidence that physical exercise played a limited role in causing salivary cortisol increases.

Similarly, no significant correlation was found between handler blood pressure and any other data. Handler heart rates were higher before the control than the test procedure; this was unexpected but contributes to the interpretation that the handlers were not unusually stressed by the test day.

Salivary Cortisol Data

Both the human and canine saliva were handled with a great deal of care to ensure validity of results. The most up-to-date methods for collecting, storing, and analyzing levels of cortisol in saliva were used (Dreschel and Granger 2009).

Human and canine salivary cortisol concentrations were not significantly correlated at any point in time. This may indicate that the dogs were not able to reliably sense the change in cortisol concentration in the handlers. It is possible that the dogs' reward after each successful search, play with the handler and a towel, may have altered the dogs' and/or the handlers' cortisol to the extent that any trends became obscured. Evidence for this possibility can be found in a study that noted that the type of play, whether punitive (involving disciplinary corrections) or affiliative, chosen by handlers to use with their dogs influenced canine cortisol in opposite directions (Horváth et al., 2008).

Salivary cortisol concentrations did not change in the dogs before and after the test procedure, indicating that individual variations may be more important to cortisol concentration than stressful external events; this is why a control day was used, so that each dog or handler may serve as its own control. The normal physiological range of salivary cortisol concentrations in dogs is difficult to define because individual variation plays such a large role; however, it is known that canine cortisol does not generally change according to a diurnal cycle as in humans (Kobelt et al., 2003).

A strong positive correlation was found between handler heart rates both before and after the test procedure and canine cortisol after the test procedure. This may indicate that the dogs were somehow able to sense the increased heart rate in the handlers or that the handlers acted differently in subtle ways that dogs are able to detect when heart rate is elevated. A study by Lit (2010) found the opposite effect: handler cortisol was associated with canine heart rates after a certification tests. These results together suggest that there is indeed interaction between the handlers' stress levels and the dogs', but the mechanism is elusive and may vary in differing situations. According to Jones and Josephs (2006), the mechanism of this exchange of emotions is likely handler behavior; specifically, rewards or punishment given to the dog after a competition or trial.

Success Ratings

High levels of performance in the dogs overall indicate the appropriateness of the handling and training methods used on these dogs. The dogs in the current study are housed with their handlers rather than in kennels so their environment generally includes a reasonable level of enrichment and human interaction. Living in a home with the handler (Lefebvre et al., 2007) and engaging in positive interaction with the handler (Haverbeke et al., 2010), as these dogs do, are factors that have been shown to maximize the efficiency of working dog/handler teams. The dogs in the current study were trained using operant conditioning with heavy reliance on positive reinforcement and, importantly, appeared to regard their handlers with respect rather than fear (Sanders 2006). While the dogs in the current study were relying on their senses to perform their searches, they relied very heavily on handler signals to determine where to start or stop searching and which areas to search a second or third time. This illustrates how working dogs both actively seek information from humans and use their own judgment to successfully complete a thorough search (McMahon et al., 2010).

As previously discussed, the handlers' success rates were not analyzed in depth because their scale consisted of just three possible scores. However, analysis of the dogs' success scores, as rated from one to ten, produced interesting results. No correlation was found between canine success and handler values. Because the teams kept searching until success was reached, the dogs always received a reward and never a punishment; this may have altered levels of stress indicators in the dogs (Jones and Josephs 2006).

The dogs with the highest heart rates before the test had the highest success rates, and a positive correlation was found between canine heart rate after the control procedure and high performance on the control day. These results seem to indicate that the most excited or energetic animals exhibited the most prized traits for drug search dogs.

The success of individual dogs was highly correlated between the two days. This showed that the dogs were not able to sense that the test day represented a more serious situation to their handlers, or at least they were not able to sense this to the extent that it affected their performance.

Canine personality is a factor investigated in other studies that may play a role in canine performance. Ley (2008) and Sinn (2010) determined the major factors which make up a canine personality. Svartberg (2002) narrowed these categories further into one main factor that seemed to have a major effect on search dog success. This factor, shyness-boldness, should be investigated further in future studies to quantify this effect.

Handler Factors and Stress

STAI data revealed no trend in anxiety levels of handlers as related to their time spent in the Drug Interdiction Unit. A previous study showed that therapy dog handlers have increased cortisol as a result of therapy sessions of extended length, but each session in this study took a similar amount of time so search duration is not likely to have served as a major source of variation in handler stress levels (Haubenhofer et al., 2007). However, data analysis showed a negative correlation between the number of years spent in the unit and handler salivary cortisol after both the test and control searches. This seems to indicate that a longer time spent in this career field lowers the occurrence of acute stress hormone concentration increases associated with evaluated search procedures. This result is in accordance with a previous study that suggested that disaster dog handlers with the most stressful jobs had the lowest salivary cortisol after a certification test (Lit et al., 2010).

5

CONCLUSIONS

Two of the main hypotheses of this experiment were disproved but valuable information was obtained. Though the handlers were not significantly more stressed on the test day, we found that drug detection dog handlers report that they are less stressed than the general population. Also, the dogs' salivary cortisol concentrations were not consistently related to the handlers' salivary cortisol concentrations but were related to handler blood pressure.

Unsurprisingly, cortisol concentrations in the dogs before and after each search were relatively similar; previous studies have demonstrated that individual variation is a more important determinant of canine salivary cortisol than stressful events (Kobelt et al., 2003). The dogs' cortisol concentrations were not correlated with those of the handlers after certification testing or the control day procedure. It is possible that the dogs' cortisol levels after the searches were lowered because of the positive interactions (play) that took place after each successful portion of the search. Jones and Josephs (2006) demonstrated that positive hormone correlations occurred between agility dogs and their handlers after an unsuccessful trial, likely as a result of punishment. In the present study, dogs all eventually completed each search successfully, so they received only rewards in the course of the study.

Previous studies (Pastore et al., 2011) indicated that neither physiological nor behavioral data individually provide a complete picture of the stress levels of working dogs. For this reason, the searches performed by the dogs on these two days were filmed but the coding and analysis of each behavior of the dogs and handlers falls outside the scope of this project. In the future, these tapes may be analyzed to clarify the mechanisms of dog/human communication during a search.

While the dogs' performance success was not related to any handler stress indicators, canine success was related to canine heart rate. This may indicate that dogs with high physical activity level or mental arousal around the time of the search are most likely to perform well. No significant difference was observed in success between the two days, so the dogs were probably unable to sense that the results on test day were more important to the handlers. Canine personality as described in other studies may also play a role in heart rate and success.

Other studies have found no link between handler experience and canine success (Lefebvre et al., 2007). This study likewise uncovered no such relationship, but it was determined that handler experience was negatively correlated with handler salivary cortisol on both days. This is one indication that increased experience lowers stress levels during evaluation in handlers.

As proposed by Olson (2002), the efforts of researchers and experts in many different disciplines are essential to the health of working dogs. Continued research into working dog and handler stress, behavior/psychology, and training methods will improve canine welfare, the dog/handler relationship and overall team performance. Improved performance in disaster, police, and military working dogs will improve the safety and efficiency of officers and civilians throughout the world.

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