2004

Effects of training paradigms on performance of search dogs

Lisa Lit

EFFECTS OF TRAINING PARADIGMS ON PERFORMANCE

OF SEARCH DOGS

A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Psychology:

General Experimental Psychology

---

by

Lisa Lit

September 2004

EFFECTS OF TRAINING PARADIGMS ON PERFORMANCE

OF SEARCH DOGS

A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

---

by

Lisa Lit

September 2004

Approved by:

[redacted]

7/21/04

Dr. Cynthia Crawford, Associate Professor, Psychology

Date

[redacted]

Dr. Sanders McDougall, Professor, Psychology

[redacted]

Dr. John Clapper, Assistant Professor, Psychology

ABSTRACT

The performance of search dogs trained to locate only live scent (live-only dogs) was compared to that of search dogs trained to locate either live or cadaver scent depending on the verbal cue given by the handler (cross-trained dogs). Twenty-three dogs (11 live-only and 12 cross-trained) searched for live scent in four different scenarios: no scent, live scent, cadaver scent, and live/cadaver scent. Each dog ran each scenario twice. Neither handlers nor observers knew the conditions of the scenarios. Live-only dogs significantly outperformed cross-trained dogs in the no scent, cadaver scent, and live/cadaver scent scenarios. There was no significant performance difference between live-only and cross-trained dogs in the live scent scenario, confirming efficacy of the cross-trained dogs with only live scent. The inferior ability of cross-trained dogs to detect live scent when cadaver scent is present strongly suggests that cross-trained dogs should not be deployed where cadaver scent is present, but live scent is the desired target. The primary example of this situation is a disaster deployment of search dogs to locate surviving victims.

ACKNOWLEDGEMENTS

This study was funded by a grant from ASI at California State University. In addition, I would like to acknowledge my committee members, Dr. Cynthia Crawford (Committee Chair), Dr. Sanders McDougall, and Dr. John Clapper. Dr. Crawford's belief and interest in this research topic, and her advice and guidance on all matters that arose during my years at California State University San Bernardino, were instrumental in my reaching this end goal. Dr. McDougall was responsible for my initial decision to apply to the Experimental Psychology program. He listened when I appeared in his office talking about dog research, and encouraged me to apply as a result. He, like Dr. Crawford, has been an untiring source of help and encouragement in negotiating the requirements of our program. Dr. John Clapper has also been an invaluable source of knowledge and inspiration. He made me aware that an 800 was possible, and his sense of humor was often a welcome relief during difficult moments.

I would also like to acknowledge the handlers and dogs that participated in this research, and the many others that were critical for the successful running of this study. I would especially like to thank Debby Boehm, Holly Howell, and Paula O'Brien for their continued support and assistance.

I am also grateful to the administration and faculty of the biology department, who allowed me to supplement my coursework with an intense array of biology coursework. In particular, I would like to thank Dr. Jeff Thompson, Dr. Nicole Bournias, Dr. Colleen Talbot, and Dr. Richard Fehn.

Finally, I must especially thank my children, Adam and Rebecca, who have become very independent during the past two years. They have offered a continual supply of love, assistance, and reasons to keep going.

TABLE OF CONTENTS

ABSTRACT iii

ACKNOWLEDGEMENTS iv

LIST OF TABLES ix

LIST OF FIGURES x

CHAPTER ONE: SEARCH DOG APPLICATIONS AND BEHAVIOR PARADIGMS

Human Scent Detection by Search Dogs 1

Behavior Paradigms for Search Dogs 3

CHAPTER TWO: BEHAVIORAL, COGNITIVE, AND NEUROPSYCHOLOGICAL CONSIDERATIONS OF THE SEARCH DOG TASK

Configural Learning and Search Dogs 9

Physiological Considerations for Configural Learning 12

Configural Learning and the Go/No-Go Effect 15

Configural Learning and Stress in Training 16

Relevance 17

CHAPTER THREE: EMPIRICAL DATA ON SCENT DETECTION DOGS

Empirical Data - Scent Detection Dog Training Performance 19

Empirical Data - Scent Detection Dog Selection 24

Relevance 28

CHAPTER FOUR: OBJECT PERMANENCE AND SEARCH DOGS

Object Permanence and Search Dog Training 29

Object Permanence Overview 30

Object Permanence in Dogs 31

Relevance 37

CHAPTER FIVE: SOCIAL COMMUNICATION AND SEARCH DOG TRAINING

Abilities of Domestic Dogs to Respond to Human Social Cues 40

An Evolutionary Explanation for Social Cue Comprehension 42

Canine Learning Via Human Social Cues 45

Relevance 46

CHAPTER SIX: SUMMARY AND HYPOTHESES 48

CHAPTER SEVEN: METHOD

Subjects 51

Apparatus and Materials 52

Procedure 55

Experimental Design 56

Statistical Analyses 58

CHAPTER EIGHT: RESULTS

Sample Description 60

Overall Mean Performance Comparisons on the Four Scenarios 64

Successful Runs 66

Analysis of Dog Errors 67

Inconsistent Dog Results 71

Performance Correlations with Handler and Dog Factors 72

CHAPTER NINE: DISCUSSION

General Discussion 77

Summary and Recommendations 87

APPENDIX A: INFORMED CONSENT FORM 91

APPENDIX B: CANINE HISTORY FORM 94

APPENDIX C: BEHAVIOR CHECKLIST 97

APPENDIX D: DEBRIEFING STATEMENT 99

APPENDIX E: STARTING INSTRUCTIONS 101

REFERENCES 103

LIST OF TABLES

Table 1. Dog sample descriptive statistics for live-only (*n*=11) and cross-trained (*n*=12) dogs 62

Table 2. Handler descriptive data 63

Table 3. Training method descriptive data 64

Table 4. Summary of search results comparing number of successful runs for live-only (LO) dogs (*n*=11,total possible correct runs for each scenario=22) with cross-trained (XT) dogs (*n*=12, total possible correct runs for each scenario=24) 67

Table 5. Summary of search errors comparing live-only(LO) dog errors to cross-trained (XT) dog errors in all scenarios 70

Table 6. Summary of inconsistent responses between the first time and the second time a scenario was run for live-only (LO) dogs (*n*=11) and cross-trained (XT) dogs (*n*=12) 72

Table 7. Correlations for live-only dogs (*n*=11) 74

Table 8. Correlations for cross-trained dogs (*n*=12) ... 76

LIST OF FIGURES

Figure 1. Mean correct runs of live-only dogs (open bars) (n=11) and cross-trained dogs (solid bars)(n=12) in each scenario (A=No Scent, B=Live Scent, C=Cadaver Scent, D= Live/Cadaver Scent).
*Significantly different from dogs using alternate training paradigm in same scenario 65

CHAPTER ONE

SEARCH DOG APPLICATIONS AND BEHAVIOR PARADIGMS

Human Scent Detection by Search Dogs

Dogs work in a variety of scent-detection situations, such as explosives, drugs (Otto, Brown, & Long, 2002), and snakes (Engeman, Vice, York, & Gruver, 2002). One of the more critical scent detection tasks for which dogs are trained is that of locating humans. Within the category of dogs trained to find humans, there are a variety of subcategories based on different parameters and situational factors. These subcategories include tracking, trailing, and air-scent search dogs.

Dogs trained to track a particular human theoretically follow the scent trail of an individual by distinguishing the scent of that individual from others (Davis, 1974). Thus, tracking dogs require articles containing the scent of the desired individual (ARDA, 1991). These dogs then follow scent from a predefined start point, by tracking footsteps left by the targeted person. It remains unclear whether the tracking dog is actually following residual scent on each footstep, broken vegetation or disturbed earth along the footstep track, or some combination of these and other factors.

Trailing dogs perform a closely related task, by following skin rafts discarded by humans (ARDA, 1991). Skin rafts are small dead skin cells shed continually by humans. It is estimated that at least 40,000 skin rafts are shed per minute. These skin rafts contain bacteria that contribute to the unique odor of humans. It is believed that this odor is unique to each human, and this odor is the scent recognized by a dog. Trailing dogs, although still searching for a specific individual, follow skin rafts left by the targeted person along their route, rather than following footsteps (Syrotuck, 1972).

Dogs can also be trained to search more generally for the scent of any individual in an area. These dogs, referred to as "air scent dogs," do not require a scented article, tracks, or a start point (ARDA, 1991; Syrotuck, 1972). Air scent dogs search an area indicated by their handlers, offering some operant response if they detect the scent of any live individual within their search areas. They can be trained specifically to seek out lost individuals in wilderness situations, hidden individuals in law enforcement scenarios, or buried victims on a disaster site.

Another application of scent detection dogs is the location of deceased humans. These dogs, known as "cadaver dogs," are conditioned to offer a specific operant response (e.g., lying down and barking) upon detecting human remains, including body fluids, decaying flesh, and blood (Rebmann, David, & Sorg, 2000).

Behavior Paradigms for Search Dogs

Dogs are often trained across multiple applications, including having to search for different scents. In some cases, dogs can be trained on a variety of scents bearing no resemblance to each other, such as a dog trained to detect hidden humans, guns, money, and drugs. In other cases, the different scents a dog is trained to locate can represent the same continuum, such as live and cadaver human scent. In this case, these dogs, referred to as "cross-trained live/cadaver dogs," are trained to search for both live and deceased victims (CARDA, 2003).

The behavior paradigms supporting these differing applications vary widely. For example, tracking and trailing dogs are essentially performing a modified match-to-sample exercise (Vauclair, 1996). Paradigms for other search dog exercises range from simple discrimination exercises to complex multiconditional discriminations. The most basic scenario is a search dog trained to detect only one scent or group of scents, and perform a specific response upon locating the trained scent or family of scents. This scenario, representing a simple learned association, requires the dog to discriminate the target scent or group of scents from other distraction scents. Regardless of whether the dog is searching for one scent or more than one scent, the same operant response is required for reinforcement. Specifically, if the dog smells scent S, he is to offer operant response R in order to obtain the reinforcement O. This may or may not be put under the control of a verbal cue C representing the discriminative stimulus in this case, so that $C \rightarrow S \rightarrow R \rightarrow O$. This association can then be linked to other contextual cues, such as a particular collar or other canine garb worn for searching.

Dogs are also trained to do biconditional operant discriminations. Here, the dog is trained to detect two different scents or groups of scents and offer a different operant response for each scent. This is often put under the discriminative stimulus control of different verbal cues. If given one verbal cue C1, the dog is to search for one particular scent or group of scents S1. If the target scent is located, the dog is to execute a specific trained operant response R1 in order to receive a reinforcer O (C1→S1→R1→O). If given a different verbal cue C2, the dog is to search for a different particular scent or group of scents S2. If this second target scent is located, the dog is to execute a different specific trained operant response R2, although usually receiving the same reinforcer (C2→S2→R2→O). Context cues can also act as discriminative cues to enhance the differences between verbal cues, so that one collar might be worn to search for scent S1, while a different collar would be used to search for scent S2.

Some handlers go further, implementing a multiconditional discrimination training paradigm. These dogs are taught to scent discriminate more than two scents or groups of scents depending on the verbal cue issued. They are expected to offer different operant responses depending on which scents are detected and which verbal cues are given. An example is a law enforcement canine expected to do a building search for a hidden individual, gun, or drugs depending on which command is given.

While theoretical demonstrations of successful biconditional discriminations have been successfully achieved in a variety of organisms such as rats, rabbits, and humans, at least one particular problem represented by potential real-life situations has not been modeled (Honey & Watt, 1999; Lober & Lachnit, 2002; Saavedra, 1975). Specifically, search dogs are often trained using a biconditional discrimination paradigm to locate either live human scent or cadaver scent, depending on the verbal cue issued by the handler. Such cross-trained dogs can be deployed in disaster situations. These situations, such as the devastation following an earthquake or terrorist attack, typically involve overwhelming amounts of cadaver scent. A cross-trained dog is then expected to search for survivors among the rubble and dead victims. In such a situation, the dog must withhold responding in the presence of what might be an extreme amount of a stimulus, cadaver scent, previously resulting in reinforcement for a trained operant response. This response must be withheld over extended periods of time as the dog searches for survivors. An incorrect response, indicating the presence of a live victim where there is none, can result in often-dangerous allocation of precious resources to locate and extract a nonexistent live victim.

Moreover, because the use of biconditional discrimination in a search dog scenario represents an applied problem, not a theoretical one, it requires a more thorough consideration of other possible factors attenuating success rates in actual field application. Although indications of performance degradation using varying learning paradigms in the laboratory might be within acceptable parameters, such degradation in a disaster scenario could potentially result in the tragic consequence of a dog failing to alert on a living victim. Such degradation might arise from factors embedded within an olfactory biconditional operant discrimination, cognitive abilities of dogs, training methods, and interference from extraneous factors. It is possible that utilizing biconditional discrimination in search dogs compromises performance to a degree that, while acceptable under laboratory conditions, is not acceptable in the applied, real-world disaster scenario.

CHAPTER TWO

BEHAVIORAL, COGNITIVE, AND NEUROPSYCHOLOGICAL CONSIDERATIONS OF THE SEARCH DOG TASK

Configural Learning and Search Dogs

When search dogs must develop an understanding of the relationships between different stimuli and their individual reinforcement contingencies, the issue of how compound stimuli are represented becomes an important factor in developing training paradigms for optimum field performance. Theoretical explanations of how combinations of stimulus compounds affect learning can be divided into two basic groups: elemental and configural.

Elemental theories of compound conditioning consider individual stimulus elements as developing individual associations with reinforcers (Mackintosh, 1975; Pearce & Hall, 1980; Rescorla, 1973). The associative strength of the compound is then the summation of individual element associative strengths. This explanation, however, does not explain the ability to resolve a biconditional discrimination problem (Saavedra, 1975). Biconditional discriminations (AB+, CD+, AD-, CB-) have each element reinforced 50% of the time, so that summations of element associative strengths should result in intermediate responses to all compounds.

Configural theories do not consider effects of summations. They instead state that various configurations of compound stimuli are represented by formation of associations between individual elements (Pearce & Wilson, 1990). Configural association theory divides associative learning into two functionally distinct categories, proposing the existence of different physiological learning and memory systems for each category. Simple association learning is mediated by the simple association system (SAS), while configural association learning operates under the auspices of the configural association system (CAS) (Sutherland & Rudy, 1989). For example, with search dogs, a simple association consists of a fixed contingency between a stimulus element (one trained odor or group of odors) and reinforcement for performing an operant behavior (alerting) upon detection of the stimulus element.

A configural association represents a problem where stimulus elements bear some specific relationship to each other, and this relationship defines reinforcement contingencies. The requirement that search dogs perform different operant behaviors upon detection of different scents, depending on a specific cue issued by the handler, while ignoring a previously reinforced odor, represents a configural association. Dogs in this situation must not only construct representations of the individual cues, odors, and operant responses, they must maintain associations between configural and simple associations.

Therefore, the biconditional discrimination problem faced by cross-trained search dogs represents one example of a configural problem. When the individual odor elements of live and cadaver can be presented together, the dog is required to offer a different trained operant behavior depending on the verbal cue (find live, find dead). Both odors present together effectively provide the dog with a compound stimulus consisting of the separable elements of live odor and cadaver odor, along with the stimulus unique to the combination of live and cadaver odors (Rescorla, 1973). Because this includes withholding the trained operant response to the uncued odor, if present, this task also represents a variant of discrimination-reversal learning.

Although dogs have clearly displayed the ability to condition to various combinations of such configural situations, simple discriminations are more rapidly and reliably learned than compound discriminations (Woodbury, 1943). The difficulty in acquiring compound discriminations arises in part from the tendency to generalize responses across discriminations. Once dogs have learned to attend to configural relationships, however, literature suggests that they would then attempt to utilize configural solutions to solve problems that could be solved using simple associations (Alvarado & Rudy, 1992).

Physiological Considerations for Configural Learning

While there are different theories proposed to explain the nature of the compound stimulus relative to its elemental components (Kehoe & Gormezano, 1980; Pearce & Wilson, 1990; Rescorla, 1973), research has clearly demonstrated that different neurological systems mediate the SAS and the CAS. The hippocampus has been demonstrated to be essential for many facets of configural learning such as discrimination-reversal learning

(Davidson, McKernan, & Jarrard, 1993; Sutherland & Rudy, 1989). More importantly, the hippocampus has been shown to be unnecessary for simple association learning (Sutherland & Rudy, 1989).

The use of the olfactory system by search dogs presents other considerations. The lateral entorhinal cortex, a primary segment of the olfactory cortex, projects directly to the hippocampus (Carlson, 2001). Although this allows olfactory sensory information to bypass the thalamic relay needed for other sensory modalities, the olfactory cortex can both discriminate and categorize odors (Larson & Sieprawska, 2002). In spite of this, the hippocampus is critical in solving configural problems using olfactory cues as well as visual cues (Dusek & Eichenbaum, 1998).

Research in mice suggests that difficulty in successful simultaneous-cue discrimination might arise from lack of distinction between odor cues (Larson & Sieprawska, 2002). This lack of distinction compromising simultaneous-cue discrimination might affect performance of cross-trained search dogs in the presence of both live and cadaver scent. In addition, it remains unidentified what components of the live human versus the cadaver scent the dog is using for discrimination. Further adding to possible olfactory-based difficulties in simultaneous-cue discrimination, when a combination of two odors is presented repeatedly, the perceived similarity of the odors increases (Stevenson, Case, & Boakes, 2003). When the odors are then presented individually, odor distinctiveness is reduced and ability to discriminate is negatively affected.

In addition to the hippocampus, the cortical cholinergic system is utilized for configural association learning, but not simple association learning (Butt & Bowman, 2002). It is suggested that such specific impairment arises from disruptions in attention systems, such as selective and divided attention. The ability to attend to relationships between more than one stimulus and corresponding reinforcement contingencies is at least in part mediated by prefrontal cortex levels of acetylcholine, with such cholinergic input not required to learn simple associations (Sarter & Bruno, 1997).

Other neuropsychological considerations might affect search dog performance. Ventral striatal neurons display firing selectivity in response to odors predictive of appetitive outcomes, and reverse firing selectivity when odor-outcome contingencies are reversed. Additionally, odor cues and associated motor responses are possibly encoded in ventral striatal neurons (Setlow, Schoenbaum, & Gallagher, 2003).

Configural Learning and the Go/No-Go Effect

The ability of specific neurons to develop firing selectivity in response to specific trained odors can contribute to difficulty in the dog withholding a motor response to a previously rewarded odor cue. When live odor and cadaver odor are present simultaneously, the command to only find one scent acts both as a go cue for one odor while presenting a no-go cue for the uncued odor. Behavior inhibition represents a highly advanced cognitive function (Rubia, Smith, Brammer, & Taylor, 2003). The ability to withhold responding in a go/no-go task involves the prefrontal cortex, parietal lobe, and temporal lobe (Rubia et al., 2003). This coordination of brain systems results from the demands of response selection, response competition, and other cognitive functions accompanying response inhibition. In particular, the right inferior prefrontal cortex appears specifically related to inhibition success or failure of motor response in a go/no-go task (Rubia et al., 2003).

The pattern of brain activation resulting from the go/no-go paradigm is also task-dependent (Mostofsky et al., 2003). Simple tasks with a low working memory load, such as that required by simple operant associations, generated fMRI responses in the left sensorimotor cortex in humans (Mostofsky et al., 2003). Complex tasks with a high working memory load, such as those required by configural problems, showed similar response, with additional no-go activation in the right dorsolateral prefrontal cortex (Mostofsky et al., 2003).

Configural Learning and Stress in Training

One other issue to be considered is training method. One dog-training tool commonly utilized is the shock collar. It has been clearly demonstrated that shock increases cortisol levels in dogs (Beerda, Schilder, Van Hooff, de Vries, & Mol, 1998; Dess, Linwick, Patterson, & Overmeier, 1983). When cortisol release is stimulated repeatedly over time, a wide variety of negative effects can result. These negative effects include deficits in conditioned responses, hippocampal damage resulting in loss of dendritic branches, and neuronal loss within the CA3 region of the hippocampus, as well as reductions in brain-derived neurotropic factor (BDNF) levels, linked to depression and possibly further contributing to hippocampal atrophy (Bremner, 1996; Brewin, Dagleish, & Joseph, 1996; Watanabe, Gould, & McEwen, 1992). Because the hippocampus has specifically been linked to performance in a configural task (Davidson et al., 1993; Dusek & Eichenbaum, 1998; Sutherland & Rudy, 1989), these data suggest that use of shock in training a search dog might ultimately compromise that dog's ability to perform configural tasks.

Relevance

All these factors, when viewed together, demonstrate the task required by a cross-trained dog when executing a biconditional or multiconditional discrimination task is far from trivial. The biconditional discrimination task is itself a configural representation problem. It includes elements of discrimination reversal and go/no-go paradigms embedded within it. Each of these tasks has been demonstrated to utilize different neural networks.

The very training attempting to instill the desired behaviors (e.g., shock) might attenuate the function of select neural networks. These conjoined learning paradigms present a cross-trained dog with a task vastly more complex than a simple operant association. These behavioral, cognitive, and neurological factors might, together, result in simple and especially biconditional discrimination success rates drastically lower than those seen in a controlled laboratory setting.

CHAPTER THREE

EMPIRICAL DATA ON SCENT DETECTION DOGS

Empirical Data - Scent Detection Dog Training and Performance

Currently, there is little published empirical data examining scent-detection canine training and performance; moreover, what literature exists offers conflicting results. For example, early studies suggested that abilities of specially trained dogs to discriminate between individuals based on scent were highly developed, such that the odors of identical twins presented simultaneously during a tracking test could be discriminated (Kalmus, 1955). Further evaluation showed that although dogs could apparently discriminate between identical twins if their environmental factors differed, they could not discriminate if environmental factors of identical twins were kept constant (Hepper, 1988). However, dogs could discriminate between fraternal twins, even under identical environmental factors (Hepper, 1988).

These results were further conflicted when dogs trained to discriminate between two different, unrelated individuals using scent from their hands were then unable to discriminate using scent from other parts of their bodies (Brisbin & Austad, 1991). This suggested that either there are no "generalized scent signatures" (Brisbin & Austad, 1991, p. 192), or specific training would be required to develop abilities in dogs to recognize such generalized signatures.

Because scent-matching abilities of dogs are used in various law enforcement efforts, this raised doubts regarding the efficacy of using dogs in such endeavors (Schoon, 1996; Taslitz, 1990). Initial misinterpretation of the data was clarified by further research yielding successful canine scent discrimination rates ranging from 80% to 85% (Settle, Sommerville, McCormick, & Broom, 1994; Sommerville, Settle, Darling, & Broom, 1993).

To resolve testing ambiguity and develop a more effective means of utilizing canine scent discrimination abilities in forensic tasks such as a police identification lineup, a four-condition discrimination task was designed (Schoon, 1996). Eight dogs certified by law-enforcement as "human scent tracker dogs" (Schoon, 1996, p. 259) were tested using these four different conditions, which included a negative control, a scent-matching exercise, a positive check design, and a positive check design reversal. For the negative control condition, 12 different scents were presented, none of which matched the sample initially offered to the dog. In the scent matching exercise, one out of six presented scents always matched the sample scent. The positive check condition required the dog to first match a sample other than the scent of the suspect, while the suspect's scent was one of the incorrect choices in the six scents presented. With the positive check design reversal, the dog is initially required to locate the suspect's scent from among six scents, and subsequently asked to match one of the other initial scents while ignoring the suspect's scent.

Results showed a staggering 60% error rate on the negative control, so that dogs consistently matched some scent when none presented was correct. The other three conditions resulted in incorrect responses 45%, 18%, and 21% of the time. Thus, while successful discrimination rates were certainly better than chance in three out of four conditions, they were far from demonstrating complete infallibility on the part of the dogs. Additionally, when there was no "suspect" present in the lineup (that is, a "null search"), the dogs found a match over half the time.

This scent discrimination exercise utilized a combination of two different learning paradigms (Schoon, 1996). The negative control represented a go/no go task, where the dog was required to either find something or not. The other three conditions represented a match-to-sample task, where the sample was initially offered to the dog, and the dog then had to match one of the presented samples to the initially offered scent. These results suggest that a no go state within a go/no go task is the most difficult of the four conditions for the scent discrimination dog; yet other research indicates that the go state of a go/no go task also presents problems for trained detection dogs.

The scent detection dog, which only has to indicate whether or not some scent or family of scents is present, essentially is performing a go/no go task. One example of scent detection dogs is their use in detecting brown tree snakes inadvertently being transported out of Guam (Engeman, Rodriquez, Linnell, & Pitzler, 1998; Engeman, Vice, York, & Gruver, 2002). Because accidental introductions of brown tree snakes resulted in deleterious effects on local wildlife in other locales, scent-detection dogs were trained and deployed to find snakes in various cargo and shipping locations (Engeman et al., 1998).

Controlled studies of the efficacy of these dogs on two separate occasions yielded successful performance rates of only 61% and 64% (Engeman et al., 2002). These studies placed snakes in predetermined cargo locations, and utilized hidden observers watching activities of dog/handler teams. A determination was made that although handlers were doing an efficient job of directing dogs to search cargo areas, dogs were failing to offer a trained alert indicating the presence of a brown cargo snake. So, in this go/no go task, even when the desired scent was present (the go state of the paradigm), highly-trained and certified dogs failed to alert on the presence of their trained scent almost 40% of the time.

Other research assessing another scent-detection dog discipline, tracking, shows similar problematic results. Although success rates for tracking dogs have not been empirically examined, only 8 out of 22 (36.3%) certified police tracking dogs were able to correctly determine the direction in which a human track had been laid (Wells & Hepper, 2003). This issue is certainly of importance in relying on tracking dogs, since following a track in the incorrect direction is generally a futile exercise. Furthermore, seven out of eight successful dogs were male, and seven (six males and one female) out of eight successful dogs were under two years of age, suggesting that ability to determine directionality of a track is both age- and sex-related. One possible explanation for the age effect was that many dogs were inadvertently affected by subtle, unintentional handler cues; perhaps the younger dogs had not been working with their handlers long enough to detect such subtle cues.

Empirical Data - Scent Detection Dog Selection

Attempts to develop reliable tests for successful selection of working dog breeding stock and evaluation of potential working dogs have also shown conflicting results. A variety of behavior tests and genetic evaluations have been suggested in attempts to identify puppies and dogs most likely to be successful as working canines in various disciplines (Coren, 1994; Mackenzie, Oltenacu, & Houpt, 1986; Murphree & Dykman, 1965; Reuterwall & Ryman, 1973; Scott & Fuller, 1965; Willis, 1989; Wilsson & Sundgren, 1997a). Although few of these studies were specific for particular working dog disciplines, they generally all attempted to test various responses in dogs to items such as reaction to a loud noise, startle response, possessiveness of an object, and reaction to attack on the handler. They also group these responses according to operationally defined characteristics such as courage (fear response), sharpness (aggressive response), defense drive (desire to defend either the dog itself, the dog's possessions, or the dog's handler), and prey drive (desire to play games labeled "competitive," such as tug-of-war games) (Wilsson & Sundgren, 1997a).

These characteristic groupings have no grounding in psychological research, nor do they account for physiological responses of the dogs, prior handling and training, or situational variability. Although such factor analyses do indicate trends in different working dog disciplines (Wilsson & Sundgren, 1997a), they do not attempt to account for the vast numbers of dogs that are rejected for service dog work for various medical and behavioral reasons.

There is some research examining heritability of working dog characteristics. Heritability is the "proportion of phenotypic variation in a population attributable to genetic factors" (Russell, 2002). A data set of over 5,000 dogs attempting to develop heritability estimates of hunting performances in Finnish Hounds found highest heritabilities for some traits only in the range of 0.11-0.15 (Liinamo, Karjalainen, Ojala, & Vilva, 1997). Similar heritability estimates were obtained when evaluating service dog characteristics, with estimates ranging from 0.15 to 0.32. Ironically, these authors came to different conclusions regarding their similar heritability estimates (Wilsson & Sundgren, 1997b). Liinamo et al. (1997) concluded that their estimates indicate that using performance testing as a primary measure for breeding considerations might not be optimal. Wilsson and Sundgren (1997b), on the other hand, stated, "complex behavioural patterns in dogs can be subjectively evaluated by an experienced person and that no more than a few characteristics are needed in order to describe the differences between dogs" (p. 235).

Liinamo et al. (1997) also found a significant effect of age, so that scores improved significantly up to four years of age, and leveled off after that. This lack of correlation of puppy testing and selection testing has been reported in other studies, indicating that such testing measures are not indicative of future performance abilities (Weiss & Greenberg, 1996; Wilsson & Sundgren, 1998).

Overall, reliable behavioral measures to indicate future success of a working canine have not been identified. Although some breeding programs claim success using a variety of non-homogenous character traits, there remain vast numbers of dogs, both bred in-house and subsequent acquisitions, that are unsuccessful in these working dog programs (Wilsson & Sundgren, 1997a, Wilsson & Sundgren, 1997b). Heritability estimates for behavioral traits are consistently low, indicating substantial effects of learning and environment.

Relevance

Evaluations of performance levels of working dogs, specifically scent-detection dogs, under controlled experimental conditions yield success rates often barely over 50%. Factors that might affect these performance rates include heredity, reward motivation, handler influence, varying motivation levels of the dogs, and general cognitive abilities of dogs (Schoon, 1997). The impact of these factors on a dog's ability to successfully perform is increased by the frequent confluence of varying learning paradigms in working dog tasks. The scarcity of formal experimental data, combined with the conflicting available data, yields little reliable information regarding selection, training, and performance of working dogs in general and scent detection dogs in particular.

CHAPTER FOUR

OBJECT PERMANENCE AND SEARCH DOGS

Object Permanence and Search Dog Training

One cognitive issue to be considered in evaluation of search dog performance is that of object permanence, or the ability to formulate mental representations of an object absent from the perceptual field (Piaget, 1937, as cited in Dore & Dumas, 1987). The ability of a dog to successfully find a hidden person might be affected by that dog's ability to mentally represent that hidden person. Search dogs are initially trained by visual representation of a disappearing "victim;" that is, the dog is restrained while watching a person run away from the dog and hide, and the dog is subsequently released to run to the victim (ARDA, 1991). Following this initial "runaway" stage, the dog is expected to locate hidden victims without benefit of seeing the victim run away. Object permanence literature suggests that these different training stages are actually completely different, relatively unrelated cognitive tasks.

Object Permanence Overview

Object permanence in humans and animals develops in six stages (Gagnon & Dore, 1993). During stages one and two, the subject is only aware of objects as they exist in the perceptual field. In stage three, although unable to actively search for hidden objects, subjects are able, for example, to reconstruct an invisible whole from a visible fraction. By the end of stage four, subjects can successfully complete a single visible displacement task, recovering an object that has been hidden while the subject watched. This stage would mimic the task required of the dog during the initial training described at the beginning of this chapter.

Stages five and six involve invisible displacement tasks. In an invisible displacement task, an object is first hidden in the hand or a container and then behind a screen. At the end of stage five, single invisible displacement tasks can be successfully completed. In addition, successive visible displacements, involving recovery of an object after viewing that object hidden successively in more than one location, can be resolved in stage five object permanence. Subjects can also at this point solve a sequential visible displacement, where an object is hidden and found in the same location over several trials, and then hidden in a different location. Stage six involves the ability to solve sequential and successive invisible displacement problems. Attainment of stage six implies not only an understanding of existence of an object when not directly perceivable, but a realization that an object's location can be determined from mental reconstruction of signaled, but not directly perceived, movements.

Object Permanence in Dogs

Evaluations of object permanence in animals have been conducted with a variety of species, including squirrel monkeys (Vaughter, Smotherman, & Ordy, 1972), rhesus monkeys (Wise, Wise, & Zimmerman, 1974), chimpanzees (Wood, Moriarty, Gardner, & Gardner, 1980), cats (Dore, 1986), psittacines, such as parrots (Pepperberg, 1999), and dogs (Gagnon & Dore, 1992). In the earliest research on object permanence in dogs (Triana & Pasnak, 1981), both dogs and cats were evaluated to avoid general conclusions based on responses of one species. Dogs and cats were tested with object permanence paradigms used in human infant studies; these paradigms reflected increasing stages of development. Although many dogs and cats could solve the visible displacement tasks easily, none of them could solve successive invisible displacements. It remained unclear, however, whether difficulties might be due to a performance deficit, where lack of motivation was affecting results, rather than a cognitive deficit, where abilities to form mental representations were limited.

Repetition of object permanence tasks in dogs using food, rather than toys, in an attempt to clarify motivational and olfactory cue impact, indicated that these factors could have impacted previous results (Gagnon & Dore, 1993), and suggested the possibility of stage six object permanence in dogs. This possibility provided potential evidence that nonprimates, as well as primates, have cognitive prerequisites for advanced stages of cognitive development such as representative intelligence.

No interbreed difference in success rates has been seen when evaluating stage six object permanence (Gagnon & Dore, 1992). Local rule learning also does not appear to contribute to results. The limited number of trials used to evaluate object permanence does not support empirical learning opportunities, and there have been no indications that performance on invisible displacement tasks improves with the few trials that were run (Gagnon & Dore, 1992). Moreover, the number of dogs successful on a single invisible displacement task after exposure to only one visible displacement task would demonstrate a surprising degree of one-trial-learning. If the dogs were learning by trial-and-error, rather than the ability to mentally represent the disappearing object, it would be expected that more than one trial would be required in order to master the task.

Yet, while performance of dogs on invisible displacement tasks remained above chance, dogs have had higher success rates on visible displacement tasks than invisible displacement tasks (Gagnon & Dore, 1992; 1993). Prior experience on visible displacement tasks yields improved performance in dogs on subsequent invisible displacement tasks (Gagnon & Dore, 1992; 1993). Search latencies are also higher on invisible displacement tasks than visible displacement tasks, indicating that they require more processing time and presented an increased degree of difficulty (Gagnon & Dore, 1993).

Important differences in object permanence abilities between canines, infants, and primates have been noted. In dogs, previous experience with simpler search behavior is necessary for improved success in invisible displacement problems, while this is not necessary in primates and human infants (Gagnon & Dore, 1992; Wood et al., 1980). Also, dogs had lower success rates and longer search latencies on invisible displacement problems, indicating increased difficulties in solving such problems and possible working memory capacity limitations in dogs not seen in primates or infants.

The object permanence cognitive function in dogs, at least through stage four and partially through stage five, appears to develop according to a predictable delineation between four weeks through nine months of age (Gagnon & Dore, 1994). Four-week-old puppies display competence at stage two. Progress was essentially one stage per week through eight-week-old puppies. Eight-week-old puppies showed successful mastery of all visible displacement tests presented. However, none of the puppies, including the nine-month-old puppies, was able to perform invisible displacement tasks, suggesting that further work was needed to determine if and when invisible displacement capability emerged in the domestic dog.

Other cognitive factors contribute to object permanence performance in dogs, such as working memory and spatial information encoding. Dogs appear to encode information regarding the hidden object in working memory, with this encoded information subject to retroactive interference (Gagnon & Dore, 1993). Dogs encode information on hidden objects in object permanence tasks using egocentric (spatial encoding based on their own spatial location) rather than allocentric (spatial encoding based on relationships to surrounding objects) encoding (Fiset, Gagnon, & Beaulieu, 2000). While dogs encode both egocentric and allocentric information in order to locate a hidden object, they rely primarily on egocentric information in their search behavior unless this form of searching is somehow made impossible. At that point, the dogs are able to utilize allocentric encoding to locate hidden objects.

When tested with retention levels as long as four minutes in a visible displacement task (dogs were required to wait for intervals as long as four minutes before being allowed to find a hidden object), dogs' performance remained significantly above chance, indicating working memory duration of at least four minutes (Fiset, Beaulieu, & Landry, 2003). Dogs do not seem subject to intertrial proactive interference, so that spatial information used in a prior trial does not affect retention of spatial information in subsequent trials (Fiset, Beaulieu, & Landry, 2003). Moreover, dogs appear to encode an approximation of hiding location, rather than the actual location.

In addition to the lack of clear evidence in support of fully developed object permanence in dogs, there has been other research demonstrating that dogs rely on information provided by humans when faced with a novel task, including keying off actions of a human (Pongracz et al., 2001; Pongracz, Miklosi, Kubinyi, Topal, & Csanyi, 2003), responsiveness to human pointing gestures (Soproni, Miklosi, Topal, & Csanyi., 2002), and use of human social cues to locate hidden food (Hare & Tomasello, 1999). Thus one question regarding object permanence is whether dogs are illustrating clear object permanence, or social learning resulting from actions of experimenters.

Relevance

Attainment of stage six object permanence by dogs is improbable, with the appearance of such object permanence capability arising from subtle use of human cues (S. Fiset, personal communication, September 8, 2003). It remains unclear if, when a scent-detection dog is given the command to find its trained scent, the dog forms a mental image and actually begins searching for the represented object. Alternatively, the dog might merely perform an operant response if it happens to detect the trained scent.

The ability to pursue an object that disappears from view, as occurs in initial training stages, is a natural predatory response in dogs representing stage four object permanence. The mental representation of the hiding location is stored in working memory, with an egocentric spatial strategy used to pursue the hidden object. This is not the same as the ability to search for a person without seeing that person disappear. Further, performing an operant response if detecting a trained scent is a simple operant association task, where the verbal representation (such as a command to "go find") is associated with some reward. Both of these tasks (stage four object permanence and olfactory recognition) represent completely different memory tasks than finding an object previously concealed.

Furthering the improbability of a search dog's ability to mentally represent an image of a hidden person, the operant association task requires recognition of an olfactory stimulus. Odors are perceptual representations, not conceptual (Zucco, 2003). As such, odors are not represented and remembered consciously, with odor recognition the only way to retrieve an odor. This suggests that the operant association involves the command and the reward, without conscious representation in memory of the odor for which the dog is searching. Although initial training utilizes stage four object permanence abilities, the ultimate search task becomes primarily an olfactory recognition problem.

The difference between the visual nature of initial training and the olfactory nature of the ultimate search task presents potential problems in progression of dogs in training. The initial training stages are not at all representative of the final desired behavior. Further understanding whether search dogs are actually forming mental images of their desired target, or simply performing a discrimination task with an operant response, might provide more useful search dog training procedures.

CHAPTER FIVE

SOCIAL COMMUNICATION AND SEARCH DOG TRAINING

Abilities of Domestic Dogs to Respond to Human Social Cues

Estimates on the origin of canine domestication vary from 12,000 years ago to over 25,000 years ago (Leonard, Wayne, Wheler, Valadez, Guillen, & Vila, 2002). One contributing factor to this domestication was the adaptive advantage offered in terms of food and safety provided for those dogs that could coexist most effectively with their human partners. Those dogs that could "read humans" had an additional advantage in their ability to maximize a peaceful coexistence (Savolainen, Zhang, Luo, Lundeberg, & Leitner, 2002). Because most domestic dogs' natural and social environment has consisted of a life integrated with a human family, it is possible that communication skills, including an ability to detect subtle human signals, evolved to enhance this coexistence (Soproni, Miklosi, Topal, & Csanyi, 2001).

This ability to read subtle human signals could unfortunately result in a search dog's excessive reliance on unintentional human cues for direction, possibly overriding perceptual inputs and conditional responses. Dogs have successfully demonstrated the ability to follow both human gaze and human gestures towards food containers (Hare & Tomasello, 1999). This is in contrast to capuchin monkeys (Anderson, Sallaberry, & Barbier, 1995), chimpanzees, and orangutans (Povinelli & Eddy, 1996; Tomasello, Call, & Gluckman, 1997). These primates were unable to successfully follow a human's gaze and pointing gestures towards a container of food.

Such cue comprehension exists in untrained family dogs (Soproni et al., 2001). A sample of dogs was tested on abilities to follow gaze and gesture, and follow gaze when an experimenter looked at, above, and below a baited bowl. Success in all cases was defined as a dog moving towards the baited bowl. Dogs were able to rapidly reach or exceed a learning criterion of 90% success when an experimenter pointed briefly and gazed at a bowl with food, with 12 of 14 dogs reaching criterion within two sessions of 10 trials each. Gaze following was only successful when the experimenter looked at, but not above or below, the baited bowl. Further research offered dogs a variety of pointing gestures to determine whether dogs actually understood the referential nature of pointing or were just following learned cues (Soproni, Miklosi, Topal, & Csanyi, 2002). Dogs responded at significant levels to "key components of these gestures…independent from presence or absence of other components and contextual changes…" (Soproni et al., 2002, p. 34).

An Evolutionary Explanation for Social Cue Comprehension

One attempt to explain apparently innate canine abilities at human cue comprehension, gaze following, and understanding referential communication suggests a social evolutionary base. The canid generalization hypothesis states that canids in general exist in social structures where survival of the group depends on both cooperation of individuals within the group and ability to understand prey behavior, and that these skills might then generalize to humans (Frank & Frank, 1982). However, these abilities specific to canine-human interactions appear enhanced in domestic dogs when compared to wolves. Early experiments comparing object-choice behavior in adult socialized wolves to object-choice behavior in domestic dogs utilized four different combinations of social cues: gaze, point, and tap the target bowl; gaze and point at the target bowl; point at the target bowl and look directly at the subject; and a control group, where no eye or directional cue was offered (Hare, Brown, Williamson, & Tomasello, 2002). A second experiment compared performance in a nonsocial task where all subjects (dogs and wolves) saw food hidden in a container and were sent to find the food after a delay. Although there was no significant difference in performance in the nonsocial food-finding task, in the social cues task dogs performed significantly better than wolves across the tasks utilizing four different combinations of social cues (Hare et al., 2002). Further testing of dogs of various ages, including puppies, on the social cues task showed no significant effect of age, suggesting an innate nature to these abilities not present in wolves (Hare et al., 2002).

Later work comparing socialized wolves to domestic dogs found that wolves were significantly less able than dogs to utilize human touching and pointing cues to find a target (Miklosi, Kubinyi, Topal, Gacsi, Viranyi, & Csanyi, 2003). In this study, dogs and wolves were trained to perform a bin-opening task and a rope-pulling task. Their performance on these tasks was not significantly different, showing that dogs and wolves were equally capable physically and mentally to perform them. They were then presented with unsolvable versions of these tasks, where the bin was locked and the rope was prevented from moving. During the unsolvable tasks, seven out of nine dogs both looked at and spent time gazing at the human present, while only two out of seven wolves even looked at the human. Thus initiating eye contact with a human and understanding referential gestures of a human appears to reflect evolutionary development of complex dog-human communication abilities not present in wolves receiving similar levels of ontogenetic socialization.

Not only can dogs recognize the referential nature of human communicative gestures such as gazing and pointing, they can learn a solution to a problem by watching a human solve it. On their own, dogs need multiple trial-and-error blocks across several sessions to solve a detour problem (e.g. Buytendijk & Fischel, 1932, as cited in Pongracz, Miklosi, Kubinyi, Topal, & Csanyi, 2003). However, human demonstration of a detour solution resulted in a significantly decreased latency of detour response in dogs with either a single detour demonstration or three detour demonstrations (Pongracz et al., 2003).

Canine Learning Via Human Social Cues

The ability of dogs to learn via social cues was further demonstrated in a comparison of learning object names by operant conditioning compared to learning object names by the model-rival method (McKinley & Young, 2003). Using the model-rival method, two humans exchange an item while asking questions about the name of the item, as the subject watches. If one person refers to the object correctly, that person receives praise from the other person. Similarly, if one person refers to the object incorrectly, that person receives facial and verbal displays of disapproval from the other person. While reward-based learning generates an association between an object's name and the reward, the model-rival method offers no such reward for learning an object's name. Dogs were taught names of two different articles, one using operant conditioning (shaping with a clicker and food) and one using model-rivalry (McKinley & Young, 2003). There were no significant differences in training times, no significant differences in training order, and no significant differences in successful retrieving of a named article from a selection of that article and three other articles. Thus dogs can learn the names of articles by watching social interactions between two humans.

Finally, a study to determine the order in which dogs utilize visual, olfactory, and human cues indicated that dogs will preferentially use visual cues to find the location of hidden food (Szetei, Miklosi, Topal, & Csanyi, 2003). Human cues were unable to override visual information provided to dogs. However, dogs followed pointing and gaze direction to a decoy location in spite of olfactory cues indicating the correct location of the food. Olfactory cues were used only in the absence of visual or human cues.

Relevance

When all this information is considered together, it overwhelmingly suggests that dogs have the ability, via an innate, complex set of dog-human interspecies communication skills, to read subtle handler cues indicating location of a victim in training. Moreover, the ability of dogs to read subtle human cues extends to cues from all humans, not just cues from the owners or handlers of dogs (e.g., McKinley & Young, 2003; Pongracz et al., 2003; Szetei et al., 2003). Therefore, dogs can potentially read these cues from other handlers aware of a training victim's location even when a dog's handler does not know the solution to a training search problem.

The tendency of dogs to utilize visual information can result in an overreliance on visual information in a search scenario. Search dog performance can be further compromised by the tendency to resort to looking towards a human when confronted with a difficult problem (Miklosi et al., 2003). These combined tendencies could potentially interfere with initial or subsequent learning of an olfactory biconditional discrimination. Ultimately, dogs might be learning to read slight gaze alternation, gestures, and other positioning and visual cues to solve discriminations, rather than actually learning to solve the olfactory biconditional discrimination itself.

CHAPTER SIX

SUMMARY AND HYPOTHESES

Olfactory perceptual acuity of search dogs is only one factor involved in a successful search execution. A dog trained to find only live scent is executing a simple association with an operantly trained response to be performed upon detection of live scent. Cross-trained dogs are trained to find more than one scent, depending on a verbal cue issued by the handler, and offer different operant responses for each different scent. This represents a biconditional discrimination, which is a form of configural learning.

Detection of a single scent and discriminating between scents are not only different learning paradigms, they utilize different neuropsychological structures as well. Although configural learning has been demonstrated in dogs in a controlled laboratory setting, the reliability of the biconditional paradigm utilized in cross-trained search dogs has not been verified empirically. The apparent inability of dogs to form mental images of hidden items, as well as the apparent inability to form mental images of odors, increases the difficulty of an olfactory biconditional task. The advanced cognitive abilities required for control in a no-go situation further enhances doubts about reliability of cross-trained search dogs seeking live victims in a scenario in which vast amounts of cadaver scent are present. This is the scenario most likely encountered in a disaster situation, in which allocation of resources to deceased victims could potentially have devastating effects on location and recovery of live victims.

Thus, although the theoretical research concerning biconditional discrimination would appear to support its successful application in dogs, in an applied situation dogs' success rates might be expected to vary considerably. The biconditional discrimination required for a cross-trained dog to execute a reliable, successful search in an applied setting can be negatively affected by a variety of factors, such as the configural nature of the biconditional task, object permanence capability in dogs, and reliance of dogs on human social cues. If this performance does, in fact, deteriorate, it can have deadly consequences for live victims in a disaster scenario. The purpose of this study was to examine whether or not training paradigm (live-only, cross-trained) affects performance of search dogs in different search scenarios (no scent scenario, live scent scenario, cadaver scent scenario, live/cadaver scent scenario). Specifically, the following hypotheses were made. There would be differences in performance as a result of training paradigm. Although performance differences between live-only and cross-trained dogs were not predicted in the no scent scenario and live scent scenario, the performance of cross-trained dogs was predicted to be worse than that of live-only dogs in the cadaver scent scenario and in the live/cadaver scent scenario.

CHAPTER SEVEN

METHOD

Subjects

Subjects were handler/search dog teams that are certified by an overseeing government agency (e.g., law enforcement) in either live-find only (live-only), or both live-find and cadaver-find (cross-trained). Eleven dogs were trained to alert on live scent only, and twelve dogs were trained to alert on live and cadaver scent. A further requirement was that the cross-trained dogs receive a different command for finding live versus cadaver, and would therefore be performing a biconditional discrimination. Because it can be difficult to find dogs meeting specified criteria for cognitive and behavioral research, number of subjects for these research projects is frequently less than 20 dogs (Brisbin & Austad, 1991; Broom, 1994; Fiset, Gagnon, & Beaulieu, 2000; Gagnon & Dore, 1993; Hepper, 1988; Schoon, 1995; Settle, Sommerville, McCormick, & Weiss & Greenberg, 1997; Slabbert & Rasa, 1997). Groups of dogs from different training organizations in the Southwest and West Coast areas were tested as they became available, with every attempt made to keep the number of live-only and cross-trained dogs equal. Search scenarios were duplicated for each group at their local testing sites.

Apparatus and Materials

In this study, the following materials were used to collect participant and canine information: an informed consent form for handlers (see Appendix A), a canine history form (see Appendix B), a behavior checklist for recording each dog's behavioral responses (see Appendix C), a handler debriefing statement (see Appendix D), and a starting instructions form (Appendix E).

In the informed consent form (see Appendix A), the following information was included: identification of the researchers, explanation of the nature and purpose of the study and the research method, expected duration of research participation, description of how confidentiality and/or anonymity will be maintained, mention of participants' rights to withdraw their participation and their data from the study at any time without penalty, information about the reasonably foreseeable risks and benefits, and the voluntary nature of their participation.

The canine history form (see Appendix B) asked for handler and canine information. Handler information included number of years handling search dogs, number of years training dogs, dog training courses attended, and participation in other canine disciplines. Canine information included dog age, breed, sex, and whether or not the dog was neutered. Dog/handler team information included training paradigm, length of time working together, certifications and titles, other disciplines, and training tools used. Each dog/handler team was assigned a number, as detailed in Appendix B (notes). Throughout the duration of data collection, each team was only identified by that number.

The behavior checklist (see Appendix C) was used to record environmental information such as room temperature, and behavior of the dog in each scenario. Possible behaviors included no alert, cadaver alert, live alert, and other behaviors as noted by the observer.

In the debriefing statement (see Appendix D), handlers were informed of the major research questions addressed in the study, and whom they could contact if they wanted to discuss or obtain the results of the study.

Moreover, to ensure the validity of the study, the handlers were requested not to discuss the details of the study with potential handlers.

The starting instructions (see Appendix E) were the instructions for each observer to ask each handler before the handler begins a search trial.

Each search scenario consisted of a similarly sized indoor area. Each scenario contained fifteen 90-ml sterile plastic specimen collection cups (Laboratory Specialists, Inc.). The lid to each cup had five holes, each approximately 0.5 cm, drilled in it. Each cup contained one 5 cm × 5 cm cotton square. The plastic cups were then concealed in two separated groups within the search scenario. One group consisted of five cups, and one group consisted of the remaining ten cups. The group of five cups was concealed within a corrugated cardboard 46.04 cm × 45.72 cm × 40.64 cm box. The group of ten cups was located together behind a barrier. In each scenario, the dog encountered the cardboard box containing the group of five cups before encountering the barrier behind which the group of ten cups was located. The four scenarios differed as follows.

1. No Scent - This scenario had no live scent and no cadaver scent. No scent was applied to the cotton squares.
2. Live Only Scent - This scenario had a hidden live victim. No scent was applied to the cotton squares. The group of ten cups was located in close proximity to the hidden live victim.
3. Cadaver Only Scent - This scenario had 0.5 ml of cadaver simulation scent (Sigma Pseudo-Corpse, #P4304) applied to each cotton pad within each cup.
4. Live and Cadaver Scent - This scenario had 0.5 ml of cadaver simulation scent (Sigma Pseudo-Corpse, #P4304) applied to each cotton pad within each cup. The group of ten cups was located in close proximity to the hidden live victim.

Procedure

Each search scenario had one observer who was responsible for recording team data while the team worked that scenario. This study was a double-blind study; neither dog/handler teams nor observers knew which conditions were present in each location.

Each subject team did two searches (each 5-min maximum) of four different enclosed, indoor areas (no scent scenario, live scent scenario, cadaver scent scenario, and live/cadaver scent scenario). Orders of scenario presentation for each participant were counterbalanced. Before each trial of each dog, the observer read the Starting Instructions (Appendix E) to the handler. The observer in each scenario completed the Behavior Checklist (Appendix C) for each trial of each dog. The following information was recorded: date, start time, total time searching, alerts issued by the dog, and other behaviors performed by the dog.

Experimental Design

A 2 × 4 mixed factorial quasi-experimental design was used to test the proposed hypotheses. The independent variables were 1) training paradigm, and 2) search scenario. The first independent variable "training paradigm" is a qualitative, categorical, between-subjects quasi-independent variable with two levels: live-only and cross-trained.[1] The second independent variable "search

[1] The independent variable "training paradigm" is a quasi-independent variable. Random assignment of dogs into the two training conditions is not possible in this study, since different training dogs are trained with different training methodologies.

scenario" is a qualitative, categorical, within-subjects variable with four levels: no scent, live scent, cadaver scent, and both live and cadaver scent. Each dog was tested twice under each search scenario.

The dependent variables were total number of successful responses of each dog in each scenario. The score range for each scenario was 0 - 2. The nature of a correct response and types of errors possible differed across scenarios. For the no scent scenario, the correct response was no alert. For the live scent scenario, the correct response was to alert and indicate the hidden person. For live-only dogs, this would be the only alert the dog is trained to offer. For cross-trained dogs, this would be the alert previously identified by the handler as the live alert. In the cadaver scent scenario, the correct response was no alert. For the live/cadaver scent scenario, the correct response was to issue a live alert and indicate the hidden person. Again, for live-only dogs, this would be the only alert the dog is trained to offer. For cross-trained dogs, this would be the alert previously identified by the handler as the live alert. Also recorded was absence of alert in the presence of the victim, alerts on cadaver scent, and false alerts (alerts either on no victim or no cadaver scent).

Other data was collected to assess correlations between various measures and performance. These data included handler information and dog information. Handler information was number of years handling search canines, number of years handling dogs in any discipline, dog training courses attended, and participation in other canine disciplines. Dog information was breed and sex of participating canines, and whether or not they are neutered. Other measures were length of time teams have been working together and training techniques used.

Statistical Analyses

A separate independent measures t-test was used to compare performance of live-only and cross-trained dogs in each scenario. Factors for the t-tests were the quasi-independent variable "training paradigm," with the levels "live-only" and "cross-trained," and the four different search scenarios (no scent scenario, live scent scenario, cadaver scent scenario, and live/cadaver scent scenario). The number of correct responses of the dogs in each search scenario constituted the raw data for these t-tests. The number of correct responses of the dogs was defined as how many times (0, 1, or 2) a dog responded correctly to the conditions of each testing scenario.

Independent measures t-tests were also used to analyze errors in each scenario. Factors for these t-tests were the quasi-independent variable "training paradigm," with the levels "live-only" and "cross-trained," and the possible errors in each scenario (live false alert, cadaver false alert, cadaver alert, no alert). The number of each type of error response of the dogs in each search scenario constituted the raw data for statistical analysis.

Additionally, a Spearman's *rho* correlation coefficient (two-tailed) was utilized to determine relationships between dog and handler information and performance.

A significance level of $p<.05$ was adopted to conclude statistical significance for the results.

CHAPTER EIGHT

RESULTS

Sample Description

This study used 23 search dog/handler teams to evaluate differences in performance between live-only (n=11) and cross-trained (n=12) dogs in four different scenarios (no scent, live scent, cadaver scent, live/cadaver scent). Each dog ran each scenario twice, for a total of 46 runs per scenario, or an overall total of 184 scenarios (46 runs per scenario × 4 scenarios). Of the 46 runs per scenario, 22 runs were by live-only dogs and 24 runs were by cross-trained dogs.

Table 1 presents descriptive information regarding the dogs used in this study. The live-only dogs had a mean age of 2.27 years; the cross-trained dogs had a slightly higher mean age of 3.42 years. A total of nine different breeds participated, with Labrador Retrievers representing 45.5% of the live-only dogs and Border Collies representing 33.3% of the cross-trained dogs. Genders were evenly divided in both live-only and cross-trained dogs, with only two dogs not neutered.

Table 2 lists handler years of experience with dogs in general, handler years of experience doing search work, and handler years working with the dog used in the study. Handlers of cross-trained dogs had a mean of 5.58 years of experience working with dogs, a mean of 4 years search experience, and a mean of 3.25 years working with the dog used in the study. Handlers of live-only dogs had fewer mean years of experience than handlers of cross-trained dogs in all categories: 3.18 years of dog experience, 2.55 years of search experience, and 1.73 years working with the dog used in the study.

Summary statistics for training methods utilized appear in Table 3. While 75% of cross-trained dogs were trained with food, only 27.3% of live-only dogs were trained with food. Approximately the same numbers of dogs were trained using physical corrective measures and shock, and all but one dog (a live-only dog) was trained using toys and verbal reinforcement.

Table 1

Dog sample descriptive statistics for live-only (n=11) and cross-trained (n=12) dogs

	Live-Only		Cross-Trained	
Dog Age	Freq.	Percent	Freq.	Percent
0-2 years	2	18.2	1	8.3
3-4 years	5	45.5	2	16.7
5-6 years	3	27.3	4	33.3
7-8 years	1	9.1	2	16.7
9-10 years	0	0.0	2	16.7
11-20 years	0	0.0	1	8.3
Total	11	100.0	12	100.0
Mean	2.27		3.42	
Median	2.00		3.00	
Dog Breed				
German Shepherd	3	27.3	1	8.3
Border Collie	0	0	4	33.3
Australian Shepherd	0	0	2	16.7
Golden Retriever	1	9.1	3	25.0
Labrador Retriever	5	45.5	0	0
Australian Cattle Dog	1	9.1	0	0
Belgian Malinois	1	9.1	0	0
Rottweiler	0	0	1	8.3
Dutch Shepherd	0	0	1	8.3
Total	11	100.0	12	100.0
Dog Gender				
Male	5	45.5	6	50.0
Female	6	54.5	6	50.0
Total	11	100.0	12	100.0
Neutered				
Yes	10	90.9	11	91.7
No	1	9.1	1	8.3
Total	11	100.0	12	100.0

Table 2

Handler descriptive data

Handler Years Dog Experience	Live-Only		Cross-Trained	
	Freq.	Percent	Freq.	Percent
0-2 years	1	9.1	0	0
3-4 years	2	18.2	1	8.3
5-6 years	3	27.3	1	8.3
7-8 years	4	36.4	1	8.3
9-10 years	1	9.1	2	16.7
11-20 years	0	0.0	2	16.7
21-30 years	0	0.0	4	33.3
31-40 years	0	0.0	1	8.3
Total	11	100.0	12	100.0
Mean	3.18		5.58	
Median	3.00		6.00	
Handler Years Search Experience				
0-2 years	3	27.3	0	0
3-4 years	3	27.3	4	33.3
5-6 years	1	9.1	0	0.0
7-8 years	4	36.4	2	16.7
9-10 years	0	0.0	4	33.3
11-20 years	0	0.0	2	16.7
Total	11	100.0	12	100.0
Mean	2.55		4.00	
Median	2.00		4.50	
Handler Years Working w/Dog				
0-2 years	6	54.5	1	8.3
3-4 years	3	27.3	4	33.3
5-6 years	1	9.1	2	16.7
7-8 years	1	9.1	2	16.7
9-10 years	0	0.0	2	16.7
11-20 years	0	0.0	1	8.3
Total	11	100.0	12	100.0
Mean	1.73		3.25	
Median	1.00		3.00	

Table 3

Training method descriptive data

Training: Food	Live-Only Freq.	Live-Only Percent	Cross-Trained Freq.	Cross-Trained Percent
Yes	3	27.3	9	75.0
No	8	72.7	3	25.0
Total	11	100.0	12	100.0
Training: Physical				
Yes	7	63.6	7	58.3
No	4	36.4	5	41.7
Total	11	100.0	12	100.0
Training: Shock				
Yes	3	27.3	3	25.0
No	8	72.7	9	75.0
Total	11	100.0	12	100.0
Training: Toy				
Yes	10	90.9	12	100.0
No	1	9.1		
Total	11	100.0	12	100.0
Training: Verbal				
Yes	10	90.9	12	100.0
No	1	9.1		
Total	11	100.0	12	100.0

Overall Mean Performance Comparisons on the Four Scenarios

Live-only dogs performed significantly better than cross-trained dogs in three out of four scenarios (see Figure 1). Specifically, live-only dogs had a greater number of successful runs than cross-trained dogs on the no scent scenario [$t(21)=2.824$, $p=.01$], cadaver scent scenario [$t(21)=3.401$, $p=.003$], and live/cadaver scent scenarios [$t(21)=3.069$, $p=.006$]. There was no significant difference in performance between live-only and cross-trained dogs in the live scent scenario.

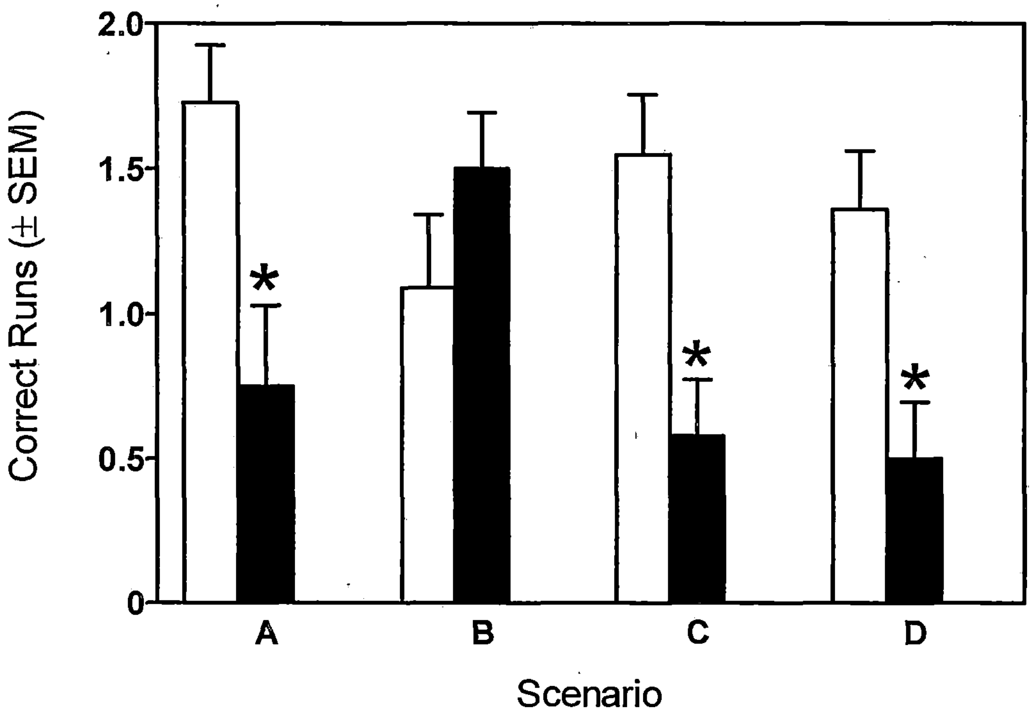

Figure 1. Mean correct runs of live-only dogs (open bars) (*n*=11) and cross-trained dogs (solid bars) (*n*=12) in each scenario (A=No Scent, B=Live Scent, C=Cadaver Scent, D=Live/Cadaver Scent).
*Significantly different from dogs using alternate training paradigm in same scenario (*p*<.05).

Successful Runs

A summary of number of successes and success rates for each group of dogs in each scenario is presented in Table 4. Out of the total of 184 scenarios run by the 23 dogs (11 live-only, 12 cross-trained), 103 scenarios (56%) were run correctly. Live-only dogs ran over twice as many scenarios correctly than cross-trained dogs in the no scent (19 vs. 9), cadaver scent (17 vs. 7), and live/cadaver scent (15 vs. 6) scenarios. Although live-only dogs did significantly better than cross-trained dogs in these scenarios, the best success rate for live-only dogs was 86% in the no scent condition, followed by a 77% success rate in the cadaver scent scenario, a 68% success rate in the live/cadaver scenario, and their lowest success rate (55%) in the live scent scenario. Contrary to this, cross-trained dogs had their best success rate (75%) in the live scent scenario, followed by 38% success in the no scent scenario, 29% success in the cadaver scent scenario, and their worst performance (25%) in the live/cadaver scent scenario.

Table 4

Summary of search results comparing number of successful runs for live-only (LO) dogs (n=11, total possible correct runs for each scenario=22) with cross-trained (XT) dogs (n=12; total possible correct runs for each scenario=24)

	# Successes		Success Rate	
Scenario	LO	XT	LO	XT
No Scent	19*	9	86%	38%
Live	12	18	55%	75%
Cadaver	17**	7	77%	29%
Live/Cadaver	15**	6	68%	25%
Total	63	40	72%	42%

*$p<.05$. **$p<.01$.

Analysis of Dog Errors

Errors occurred in 81 out of the total 184 scenarios run (see Table 5). Overall, dogs made 18 errors in the no scent scenario, 16 errors in the live scent scenario, 22 errors in the cadaver scent scenario, and 25 errors in the live/cadaver scent scenario.

Types of errors varied according to scenario. In the no scent scenario, errors included live false alerts and cadaver false alerts. Live-only dogs had two live false alerts and one cadaver false alert; cross-trained dogs had seven live false alerts and eight cadaver false alerts. However, if the live-only dog that issued the erroneous cadaver false alert is removed from the analysis, cross-trained dogs had significantly more cadaver false alerts than live-only dogs [$t(20)=-2.365$, $p<.05$].

In the live scent scenario, possible errors were live false alerts, cadaver false alerts, and no alerts. Live-only dogs had significantly more no alerts than cross-trained dogs, [$t(21)=2.653$, $p<.05$]. Here, live-only dogs had one live false alert, one cadaver false alert, and eight no alerts. Cross-trained dogs had no live false alerts, five cadaver false alerts, and only one no alert.

In the cadaver scent scenario, errors recorded were live false alerts and cadaver alerts. Cross-trained dogs had significantly more cadaver alerts than live-only dogs [$t(21)=-4.033$, $p=.001$]. Although the number of live false alerts was similar for live-only dogs (4) and cross-trained dogs (3), live-only dogs had one cadaver alert while cross-trained dogs had 14 cadaver alerts.

In the live/cadaver scent scenario, errors observed were live false alerts, cadaver alerts, and no alerts. While live-only dogs had no live false alerts and cross-trained dogs had two live false alerts, live-only dogs had two cadaver alerts compared to seven for the cross-trained dogs. However, if the live-only dog that issued the two erroneous cadaver alerts is removed from the analysis, cross-trained dogs then issued significantly more cadaver alerts than live-only dogs [$t(20)=-2.317$, $p<.05$]. In addition, live-only dogs had five no alerts compared to nine no alerts for cross-trained dogs.

Table 5

Summary of search errors comparing live-only (LO) dog errors to cross-trained (XT) dog errors in all scenarios

Error Type	Errors		
	LO (%)	XT (%)	Total (%)
No Scent Scenario			
Live False Alert	2 (9%)	7(29%)	9(20%)
Cadaver False Alert	1[a] (5%)	8(33%)	9(20%)
Live Scent Scenario			
Live False Alert	1 (5%)	0(0%)	1(2%)
Cadaver False Alert	1 (5%)	5(20%)	6(13%)
No Alert	8* (36%)	1(4%)	9(20%)
Cadaver Scent Scenario			
Live False Alert	4 (18%)	3(13%)	7(15%)
Cadaver Alert	1** (5%)	14(58%)	15(33%)
Live/Cadaver Scenario			
Live False Alert	0 (0%)	2(8%)	2(4%)
Cadaver Alert	2[a] (9%)	7(29%)	9(20%)
No Alert	5 (38%)	9(38%)	14(30%)
Total Errors	25 (28%)	56(58%)	81(44%)

[a]Significant at $p<.05$ if live-only cadaver indication is removed.

$*p<.05$. $**p<.01$.

Inconsistent Dog Responses

Ninety-two scenarios (4 scenarios × 23 dogs) were run twice, yielding the total of 184 scenarios. Of these 92 scenarios, responses of dogs differed between the first and second runs on 32 scenarios (35%) (see Table 6). In the no scent scenario, inconsistent responses were observed for four dogs: one live-only dog and three cross-trained dogs. In the live scent scenario, inconsistent responses were recorded for five live-only dogs and four cross-trained dogs, for a total of nine dogs. Nine dogs also had inconsistent responses in the cadaver scent scenario (three live-only and six cross-trained). There were ten inconsistent responses in the live/cadaver scent scenario, five live-only dogs and five cross-trained dogs.

Table 6

Summary of inconsistent responses between the first time and the second time a scenario was run for live-only (LO) dogs (n=11) and cross-trained (XT) dogs (n=12)

	Inconsistent Responses		
Scenario	LO (%)	XT (%)	Total (%)
No Scent	1 (9%)	3 (25%)	4 (17%)
Live	5 (45%)	4 (33%)	9 (39%)
Cadaver	3 (27%)	6 (50%)	9 (39%)
Live/Cadaver	5 (45%)	5 (42%)	10 (43%)
Total	14 (32%)	18 (38%)	32 (35%)

Performance Correlations with Handler and Dog Factors

Table 7 contains correlations between performance of live-only dogs and characteristics of dogs and handlers, although this data must be interpreted cautiously due to the small sample size. For live-only dogs, correct response in the live scent scenario was positively correlated with correct response in the cadaver scent scenario [Spearman's *rho*[9]=.644, *p*=.033]. Correct response in the no scent scenario was strongly correlated with total correct responses [Spearman's *rho*[9]=.720, p=.012]. Use of physical training methods was more likely to be associated with correct performance on the no scent scenario [Spearman's *rho*[9]=-.620, *p*=.042], while use of shock in training was more likely to be associated with correct performance in the live/cadaver scent scenario [Spearman's *rho*[9]=-.642, *p*=.033]. Dog age, years of handler search experience and years handler had been working with the current dog were all positively related to performance in the cadaver scent scenario [Spearman's *rho*[9]=.645, *p*=.033, Spearman's *rho*[9]=.745, *p*=.008, Spearman's *rho*[9]=.646, *p*=.032].

Table 7

Correlations for live-only dogs (n=11)

	Correct Responses/Scenario				
	No Scent	Live Scent	Cadaver Scent	Live/ Cadaver Scent	Total
No Scent	1.000				
Live Scent	-0.014	1.000			
Cadaver Scent	0.316	*-0.644	1.000		
Live/Cadaver Scent	-0.119	0.181	-0.012	1.000	
Total Correct Responses	*0.720	0.273	0.362	0.455	1.000
Training: Food	-0.287	0.342	-0.076	0.071	0.000
Training: Physical	*-0.620	0.158	-0.280	0.462	-0.193
Training: Shock	0.287	-0.445	0.454	*-0.642	-0.104
Training: Toy	0.148	-0.424	0.235	-0.221	-0.162
Training: Verbal	-0.593	-0.424	0.235	-0.221	-0.486
Dog Age	-0.272	-0.537	*0.645	-0.123	-0.172
Dog Breed	0.200	0.413	-0.248	-0.075	0.140
Dog Gender	0.086	-0.367	0.135	-0.319	-0.187
Dog Neutered	0.148	-0.053	0.235	0.332	0.324
Hndlr Yrs Dog Experience	0.119	0.067	0.326	0.135	0.396
Hndlr Yrs Srch Experience	-0.162	-0.432	**0.745	0.047	0.061
Yrs Hndlr Working With Dog	-0.149	-0.483	*0.646	-0.360	-0.154

*Correlation is significant at the 0.05 level.

**Correlation is significant at the 0.01 level.

There were fewer significant correlations observed for cross-trained dogs than for live-only dogs (see Table 8), although because of the small sample size, this data must be interpreted cautiously. Performance in the live scent scenario was positively associated with overall correct performance [Spearman's *rho*[10]=.683, *p*=.014].

Years of handler search experience were positively correlated with correct performance in the live scent scenario and the live/cadaver scent scenario [Spearman's *rho*[10]=.585, *p*=.046; Spearman's *rho*[10]=.697, *p*=.012], as well as overall total correct runs [Spearman's *rho*[10]=.715, *p*=.009]. In addition, female dogs were more likely to have more correct responses in the cadaver scent scenario than male dogs [Spearman's *rho*[10]=.672, *p*=.017].

Table 8

Correlations for cross-trained dogs (n=12)

	Correct Responses/Scenario				
	No Scent	Live Scent	Cadaver Scent	Live/ Cadaver Scent	Total
No Scent	1.000				
Live Scent	0.157	1.000			
Cadaver Scent	0.031	-0.007	1.000		
Live/Cadaver Scent	-0.357	0.407	-0.115	1.000	
Total Correct Responses	0.559	*0.683	0.364	0.373	1.000
Training: Food	-0.477	0.477	-0.031	0.381	0.087
Training: Physical	-0.475	-0.363	0.245	0.056	-0.254
Training: Shock	0.064	-0.477	0.217	0.127	0.058
Training: Toy	.	.	.	.	.
Training: Verbal	.	.	.	.	.
Dog Age	0.241	0.155	0.329	0.204	0.517
Dog Breed	-0.436	-0.258	0.038	0.145	-0.358
Dog Gender	0.248	-0.083	*0.672	-0.220	0.301
Dog Neutered	0.000	0.000	0.000	0.371	0.184
Hndlr Yrs Dog Experience	0.098	0.163	0.159	0.240	0.419
Hndlr Yrs Srch Experience	-0.025	*0.585	0.255	*0.697	**0.715
Yrs Hndlr Working With Dog	0.326	0.196	0.460	0.073	0.539

*Correlation is significant at the 0.05 level.

**Correlation is significant at the 0.01 level.

CHAPTER NINE

DISCUSSION

General Discussion

The purpose of the present study was to assess whether training paradigm affects performance in search dogs. Specifically, it was predicted that cross-trained dogs would perform significantly worse than live-only dogs when searching for live scent in scenarios containing either cadaver scent alone or a combination of cadaver scent and live scent. As predicted, the ability of cross-trained dogs to detect and indicate the presence of live scent was compromised when cadaver scent was present. Additionally, contrary to prediction, cross-trained dog performance was significantly below that of live-only dog performance when neither cadaver nor live scent was present.

When data from this study are considered as a whole, overall dog success rate of 56% mirrors that of other scent-detection canines evaluated under double-blind conditions (e.g., Engeman et al., 2002; Schoon, 1996). Cross-trained dogs had an overall 42% success rate, while live-only dogs had an overall 72% success rate. However, when comparing these, the most parsimonious explanation is that either the training process or the nature of the configural problem faced by cross-trained dogs, or some combination of these factors, is responsible for the degraded performance.

As indicated previously, the popular method used for training human detection dogs involves initial use of a "runaway," that is, the dog watches a person hide and is then allowed to run and find the person. This exercise, a stage four object permanence example, is not the same type of problem as the final desired olfactory recognition problem. Olfactory recognition of an additional scent, to be under the discriminative control of a verbal cue, enhances the difficulty of the task by adding a configural component.

Without well-planned training trials in the presence of both live and cadaver scents, the combination of live and cadaver scents will generate enhanced responding (Kehoe & Gormezano, 1980). Simply learning to discriminate live scent and cadaver scent separately will not necessarily generate configural solutions when faced with the configural problem presented by the presence of both (Alvarado & Rudy, 1992). Moreover, elemental solutions are generally preferred, with a switch to configural approaches only occurring when reliable elemental components cannot be isolated (assuming a configural approach has been taught) (Saavedra, 1976; Williams, Sagness, & McPhee, 1994). This is supported by the results of cross-trained dogs in both the live scent and cadaver scent scenarios. In these scenarios, cross-trained dogs alerted on the live scent correctly on 18 out of 24 runs, and on the cadaver scent (which was incorrect according to the instructions of this study) on 14 out of 24 runs. The cross-trained dogs appeared to be using an elemental solution to a configural problem; that is, they were using simple scent discriminations to determine response, rather than solving a discrimination problem based on the verbal cue issued by the handler.

While use of an elemental solution may be due to lack of controlled trials to teach a configural solution, it may also be in part due to the nature of the olfactory recognition task. It is possible that the salience of odors exceeds that of verbal cues, perhaps due to the preferential access that the olfactory system has to brain structures involved in learning and memory (Larson & Sieprawska, 2002).

Noteworthy, though, is the association between dog gender and cross-trained dog performance in the cadaver scenario. Female cross-trained dogs performed better than male cross-trained dogs in the cadaver scent scenario. The females were able to withhold responding in the presence of cadaver scent better than males.

Even with controlled training, however, reliability rates rarely meet those obtained when performing a simple operant association (e.g., Alvarado & Rudy, 1992; Honey & Watt, 1999; Larson & Sieprawska, 2002). Controlled empirical research on configural learning suggests that while modifications to training regimes for detection dogs might increase success rates, the reliability of detection will not reach that of dogs performing simple operant associations. Generally, reliability rates for configural problems require more training trials to approach criteria, with lowered consistency rates upon reaching that level. The enhanced noise and distraction provided by an applied canine working situation would be expected to further negatively impact performance (Maes & deGroot, 2002).

Interestingly, in the no scent scenario, cross-trained dogs issued either a (false) cadaver alert or a (false) live alert in 15 out of 24 runs. Because this scenario was included as a negative control, the tendency of these dogs to alert when no scent is present suggests a potentiated tendency to alert. This may be due to fewer unrewarded searches in training, increased tendency of handlers to believe some scent may be present, (undesired) olfactory conditioned response to some component in live and/or cadaver scent, or some combination of these factors. Wells and Hepper (2003) suggested that older dogs (over two years of age) might be more attentive to social cues issued by their handlers. Because the cross-trained dogs had a higher mean age than live-only dogs (3.42 years vs. 2.27 years), it is possible that they, too, were more affected by inadvertent handler social cues. This tendency to respond to real or imagined handler cues might be further exacerbated by the increased mean number of years handlers of cross-trained dogs had been working with their dogs (3.25 years vs. 1.73 years for live-only).

Additionally, because the no scent scenario represents a no go situation, it is possible that dogs trained with configural problems have increased inability to withhold responding. This might be due to the increased attentional requirements presented by the nature of configural problems (Butt & Bowman, 2002; Rubia et al., 2003).

The cadaver/live scenario was specifically designed to emulate the conditions found in a disaster; that is, cadaver scent and live scent were present concomitantly. Performance of cross-trained dogs was the poorest in this scenario. The presence of live and cadaver scent together posed problems in 18 out of 24 runs. Unlike the cadaver scent scenario, the biggest problem was not alerting on cadaver; rather, dogs were approximately equally likely to alert on cadaver or to issue no alert at all. These results are inconsistent with results in the no scent scenario, where over 50% of the dogs could not refrain from alerting with no scent present. In the live/cadaver scent scenario, 38% of the dogs issued no alert at all, in spite of having both cadaver and live scent present. It is possible that finding both scents together was so confusing that the dogs simply refrained from alerting rather than attempt to solve the mixed configural problem presented. It is also possible that the combination of live and cadaver scent represented a compound scent (a configural stimulus) that was not associated with any previous reinforcement.

For cross-trained dogs, in the live/cadaver scenario and for total correct responses, years of handler search experience were positively associated with correct performance. The more years of handler search experience, the better the cross-trained dogs performed the mixed configural problem, and the better total performance overall. This suggests that when handlers have more experience specifically working dogs in search situations, dogs might receive more efficacious training, so that they are less likely to become confused than dogs with more inexperienced handlers.

Also, performance in the live scent scenario was positively associated with total correct responses. Because cross-trained dogs performed so poorly in the other three scenarios, however, this association probably only reflects the weighted contribution of correct performance in this scenario to overall performance.

Live-only dogs had some performance results worth noting. Not only were physical training methods associated with increased performance in the no scent scenario, if live-only dogs performed correctly in the no scent scenario, they were more likely to have better total performance as well.

It is unclear why training using shock was related to improved performance in the live/cadaver scent scenario. It is possible that these dogs had been specifically trained with live scent as an S^D, or stimulus signaling reinforcement, and cadaver scent as one of potentially many stimuli acting as an S^Δ, or stimulus signaling shock. In this case, the presence of both scents concomitantly would narrow the generalization gradient, enhance the peak shift, and generate potentiated response to the live scent (Gerry, 1971; Grusec, 1968; Klein, 2002).

Years of handler search experience and working with dogs in general was associated with higher performance in the cadaver scent scenario. Older dogs were more likely to do better in the cadaver scent scenario. These findings are not surprising because experienced handlers and dogs might be expected to handle new or different situations with more aplomb than the novice dogs and handlers. However, higher performance of live-only dogs in the cadaver scent scenario was significantly correlated with poorer performance in the live scent scenario. This raises the possibility that dogs were not necessarily refraining from alerting on the cadaver scent. They might instead have simply been not alerting at all, a behavior that was then also displayed in the live scent scenario. This certainly puts the reliability of these dogs at issue; if they are not alerting because they are simply not working, their effectiveness in an actual disaster is questionable.

The one startling finding for live-only dogs was the number of no alerts in the live scent scenario and the live/cadaver scent scenario. The eight no alert errors made by live-only dogs in the live scent scenario, and the five no alert errors in the live/cadaver scent scenario, represent 13 live victims that might have gone undetected. Given the relative simplicity of these search scenarios, this finding suggests that in double-blind situations, the live-only dogs lose some capacity to locate hidden live victims. It is possible that the live-only dogs are relying on human cues more than previously realized. It is also possible that their training has occurred on a well-known training site, where hiding locations are finite and become recognizable to the dog.

Additionally, there were two cadaver false alerts and three cadaver alerts made by live-only dogs. These alerts were made by dogs whose handlers presented them to the study as alerting on live scent only. Because this study utilized manufactured pseudo-scent that mimics the odor of human decomposition, it is unlikely that the dogs were recognizing some component of live human in the cadaver scent. What is more likely is that the dogs had been "exposed," that is, trained to alert on cadaver scent to some limited degree. Because the smell of pseudo-scent (e.g., decomposition) is particularly salient, it is possible that even limited exposure to training with cadaver scent generates a rapid associative response in dogs. This would make it more difficult for a dog to ignore cadaver scent in an actual deployment, and further increases the need for handlers to understand that crosstraining dogs will affect reliability in the configural situation presented by an actual disaster deployment.

Summary and Recommendations

When combined with the existing literature the present results strongly suggest that dogs deployed in a disaster situation to find live victims should not be trained, even minimally, to alert on cadaver scent. Without formal training, it is unlikely that dogs will use a configural solution to the configural problem posed by combined live and cadaver scents. It is unreasonable to expect reliable detection of live victims in the presence of cadaver scent with a cross-trained dog.

There are some situations where a cross-trained dog is mandatory, specifically, the wilderness search situation. In this case, the victim may be alive or dead, and the dog needs to detect the victim and indicate the find to the handler. It is suggested that in this case, the dog should be trained similarly to drug dogs. Drug dogs are often trained to alert on a group of different drugs (a learning set). A drug dog is trained to use the same alert upon locating any single drug or combination of drugs in the learning set, and is not asked to discriminate between different drug scents. Dogs are capable of developing learning sets consisting of at least 10 scents in a controlled environment (Williams & Johnston, 2002). By grouping live scent and cadaver scent into a learning set when working a cross-trained dog, the need to solve a configural problem is eliminated. Such a dog, however, would not be able, nor should this dog be expected, to discriminate the presence of one of these scents while withholding response to the presence of the other.

Studies utilizing double-blind, controlled experimental techniques to examine scent detection abilities of dogs repeatedly demonstrate poor success rates (Engeman et al., 2002; Schoon, 1996). It is further suggested that training and evaluation measures include more trials where no humans present know the location of the hidden victim. This eliminates the possibility that dogs are using subtle human cues to locate hidden victims in training and evaluation.

An interesting finding was that dogs displayed low reliability of performance, shown by inconsistent results when required to run the same simple scenario twice. Of the 92 scenarios, each run twice, responses of dogs differed between the first and second runs on 32 scenarios (35%). Although the American Kennel Club requires repeated successful performances to receive obedience titles (American Kennel Club, 2003), search dogs are only required to have a single successful trial in order to become certified (Canine Working Group, 2003). While search dogs may need to recertify on a regular basis, there is no requirement to display any measure of consistency in order to obtain or maintain certification. As the results of this study demonstrated, the ability to perform a search once does not necessarily indicate such success can be replicated.

Finally, training and certification should include a measure to evaluate the ability of a search dog to perform effectively in a no scent scenario. As discussed, withholding response is an advanced cognitive capability, made more difficult by the ability of dogs to detect subtle human cues.

These findings support previous findings that, under controlled experimental conditions, scent detection dog performance is inadequate. This research demonstrated inferior performance of cross-trained dogs when compared to live-only dogs in three out of four scenarios. The differences in performance resulted from an inability of cross-trained dogs to utilize configural solutions for configural problems, a potentiated tendency of cross-trained dogs to alert when no scent was present, and, perhaps, an overreliance on subtle human cues. These findings also illustrated a startling level of performance inconsistency in both live-only and cross-trained dogs. I. Lehr Brisbin (Fortune, 2004), a University of Georgia working canine researcher, states, "I've been studying dogs a long time, and when I test dogs that are supposed to be able to do this [scent work] very well, they fail. Invariably." In spite of such experimental data, however, search dogs continue to be a valuable resource in a variety of human detection tasks. However, the complex learning paradigms and cognitive concepts underlying the tasks faced by search dogs must be considered in order to ultimately improve search dog performance.

APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT FORM

You are invited to participate in a research study being conducted by Lisa Lit under the supervision of Dr. Cynthia Crawford of California State University San Bernardino (CSUSB). The Institutional Animal Care and Use Committee at CSUSB, the Institutional Review Board Sub-Committee of the CSUSB Psychology Department, and the California Office of Emergency Services have approved this study. This consent form should bear the official stamp of approval from the CSUSB Psychology Department Sub-Committee.

The purpose of the study is to examine effects of training paradigms on searching. Procedures will be as follows:

1. There are four different mini-search scenarios. Each team will search each scenario twice, according to run order determined by the experimenters.
2. Each scenario will take no more than five minutes to run, so that each team will spend no more than a total of 40 minutes searching.
3. In each scenario, the handler will be requested to clear the room for live scent. If the handler feels that the dog issues an alert for live, the observer will record a live alert, and the location indicated by the dog. If the handler feels that the dog issues any other alert, the observer will record the handler's notations.

Risks involved in participation involve standard risks involved in handling search canines. It is expected that handlers have sufficient prior experience handling their canines that these risks are minimized.

At this point in time, there is no formal research examining effects of training paradigms on searching. This research will provide a valuable base for further research examining what factors affect search work, and could lead to similar research in other disciplines of working canines.

All information in the study records will be kept strictly confidential. Data will be stored securely and will be made available only to persons conducting the study unless participants specifically give permission in writing to do otherwise. No reference will be made in oral or written reports that could link participants to the study.

If you have questions at any time about this study or the procedures, you may contact the researcher, Lisa Lit, at the Psychology Office, California State University, 909-880-5570.

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at anytime without penalty. If you withdraw from the study before data collection is completed, your data will be destroyed.

CONSENT

I have read the above information. I have received a copy of this form. I agree to participate in this study. I also acknowledge that I am at least 18 years of age.

(Please place an "X" in the box to acknowledge.)

Participant: ☐ Date: ____________________

APPENDIX B

CANINE HISTORY FORM

CANINE HISTORY FORM

ASSIGNED NUMBER: __________

Handler Information

Number of Years Handling Search Canines:______________________________

Number of Years Handling Dogs(any discipline):__________________________

Dog Training Courses Attended:____________________________________

Participation in Other Canine Disciplines (with any dogs):___________________

____

Canine Information

Age:____

Breed:____

Sex: Male Female **Neutered?** Yes No

Handler/Team Information

How Long Working Together?____________________________________

Certifications, Titles, etc.:_____________________________________

Other Disciplines (drug detection, competition obedience, etc.):_____________

____

Training Methods Used (circle all that apply):

Verbal Physical Electronic Food Reward Toy Reward

Other (specify): ____

APPENDIX B (NOTES)

Each dog/handler team will be assigned a number. Once that number is assigned, it will be kept in a locked location, to which only the lead investigator will have access. That number will consist of four digits, followed by one letter.

The first two digits will represent testing location. The last two digits will represent subject number; for example, the first subject will have "01" as the number assigned. The letter will represent whether the dog is trained for live only ("L"), or cross-trained ("X").

APPENDIX C

BEHAVIOR CHECKLIST

Behavior Checklist - SCENARIO ________

Date:______________________

Researcher:____________________ **Assigned Team Number:**___________

Temperature:_____________**Weather:**________________________________

Live Alert:____

Cadaver Alert:____

Start Time:_________**AM/PM** **Total Time on Task:** ___________

Observations

No alert issued____

Live alert issued (describe)____

Cadaver alert issued (describe)____

Other Behaviors (explain)____

Notes:

APPENDIX D

DEBRIEFING STATEMENT

DEBRIEFING STATEMENT

The major research question addressed in this study is whether or not training paradigms affect performance in search dogs. To discuss or obtain results of this study, participants can contact Lisa Lit at the California State University San Bernardino Psychology Office, 909-880-5570. Results will be available July 1, 2004. In order to ensure the validity of this study, participants are requested not to discuss the details of the study with potential participants. Thank you for your participation.

APPENDIX E

STARTING INSTRUCTIONS

Instructions for Observer to ask each Handler before beginning

THANK YOU FOR RESPONDING TO THIS DISASTER. MAY I ASK YOU A FEW QUESTIONS BEFORE WE BEGIN?

- What is your assigned team number? (note on form)
- What is your dog's live alert? (note on form)
- What is your dog's cadaver alert? (note on form, N/A if Live-Only)

Your mission is to clear the assigned area for ***live*** victims. Be sure to clear all perimeter areas carefully. If any doors are closed, leave them closed, but be sure to clear around the door carefully. If any doors are open, you may enter that room and search the interior. If your dog alerts on an area, either live or cadaver, please let me know where he is indicating. You will have five minutes to clear your area. You may begin.

REFERENCES

Alvarado, M.C., & Rudy, J.W. (1992). Some properties of configural learning: An investigation of the transverse-patterning problem. *Journal of Experimental Psychology: Animal Behavior Processes, 18*, 145-153.

American Kennel Club. (2003). *Obedience regulations.* New York: American Kennel Club.

Anderson, J., Sallaberry, P., & Barbier, H. (1995). Use of experimenter-given cues during object-choice tasks by capuchin monkeys. *Animal Behavior, 49*, 201-208.

ARDA (American Rescue Dog Association). (1991). *Search and rescue dogs - training methods.* New York: Howell Book House.

Beerda, B., Schilder, M.B.H., Van Hooff, J., de Vries, H.W., & Mol, J.A. (1998). Behavioural, saliva cortisol and heart rate responses to different types of stimuli in dogs. *Applied Animal Behaviour Science, 58*, 365-381.

Bremner, J.D. (1999). Does stress damage the brain? *Biological Psychiatry, 45*, 797-805.

Brewin, C.R., Dalgleish, T., & Joseph, S. (1996). A dual representation theory of posttraumatic stress disorder. *Psychological Review, 103*, 670-686.

Brisbin, I.L., & Austad, S.N. (1991). Testing the individual odour theory of canine olfaction. *Animal Behaviour, 42*, 63-69.

Brisbin, I.L., & Austad, S.N. (1993). The use of trained dogs to discriminate human scent: A reply. *Animal Behaviour, 46*, 191-192.

Butt, A.E., & Bowman, T.D. (2002). Transverse patterning reveals a dissociation of simple and configural association learning abilities in rats with 192 IgG-Saporin lesions of the nucleus basalis magnocellularis. *Neurobiology of Learning and Memory, 77*, 211-233.

Canine Working Group. (2003). Canine working group web site: FEMA - disaster dogs. Retrieved October 4 from http://www.disasterdog.org/articles/disaster dogs 101 .htm.

CARDA (California Rescue Dog Association). (2003). CARDA web site: frequently asked questions. Retrieved March 29 from http://www.carda.org/faq.aspx.

Carlson, N.R. (2001). *Physiology of behavior* (7^{th} ed.). Needham Heights, MA: Allyn and Bacon.

Coren, S. (1994). *The intelligence of dogs.* New York: The Free Press.

Davidson, T.L., McKernan, M.G., & Jarrard, L.E. (1993). Hippocampal lesions do not impair negative patterning: A challenge to configural association theory. *Behavioral Neuroscience, 107*, 227-234.

Davis, L.W. (1974). *Training your dog to track.* New York: Howell Book House Inc.

Dess, N.K., Linwick, D., Patterson, J., & Overmeier, J.B. (1983). Immeidate and proactive effects of controllability and predictability on plasma cortisol responses to shocks in dogs. *Behavioral Neuroscience, 97*, 1005-1016.

Dore, F., & Dumas, C. (1987). Psychology of animal cognition: Piagetian studies. *Psychological Bulletin, 102*, 219-233.

Dore, F., Fiset, S., Goulet, S., Dumas, M., & Gagnon, S. (1996). Search behavior in cats and dogs: Interspecific differences in working memory and spatial cognition. *Animal Learning and Behavior, 24*, 142-149.

Dore, F.Y. (1986). Object permanence in adult cats. *Journal of Comparative Psychology, 100,* 340-347.

Dusek, J.A., & Eichenbaum, H. (1998). The hippocampus and transverse patterning guided by olfactory cues. *Behavioral Neuroscience, 112*, 762-771.

Engeman, R.M., Rodriquez, D.V., Linnell, M.A., & Pitzler, M.E. (1998). A review of the case histories of the brown tree snakes (*Boiga irregularis*) located by detector dogs on Guam. *International Biodeterioration & Biodegradation, 42*, 161-165.

Engeman, R.M., Vice, D.S., York, D., & Gruver, K.S. (2002). Sustained evaluation of the effectiveness of detector dogs for locating brown tree snakes in cargo outbound from Guam. *International Biodeterioration & Biodegradation, 49*, 101-106.

Fiset, S., Beaulieu, C., & Landry, F. (2003). Duration of dogs (*Canis familiaris*) working memory in search for disappearing objects. *Animal Cognition, 6,* 1-10.

Fiset, S., Gagnon, S., & Beaulieu, C. (2000). Spatial encoding of hidden objects in dogs (*Canis familiaris*). *Journal of Comparative Psychology, 114,* 315-324.

Fortune. (2004). This just in - Sit! Stay! Testify! Retrieved January 21, 2004 from http://www.fortune.com/fortune/thisjustin/0,15704,575713,00.html.

Frank, H., & Frank, M. (1982). On the effects of domestication on canine social development and behavior. *Applied Animal Ethology, 8,* 507-525.

Gagnon, S., & Dore, F. (1992). Search behavior in various breeds of adult dogs (*Canis familiaris*): Object permanence and olfactory cues. *Journal of Comparative Psychology, 106,* 58-68.

Gagnon, S., & Dore, F. (1993). Search behavior of dogs (*Canis familiaris*) in invisible displacement problems. *Animal Learning & Behavior, 21,* 246-254.

Gagnon, S., & Dore, F. (1994). Cross-sectional study of object permanence in domestic puppies (*Canis familiaris*). *Journal of Comparative Psychology, 108,* 220-232.

Gerry, J.E. (1971). Peak shift on the tonal-frequency continuum: The effects of extinction and punishment. *Psychonomic Science, 23,* 33-34.

Grusec, T. (1968). The peak shift in stimulus generalization: Equivalent effects of errors and noncontingent shock. *Journal of the Experimental Analysis of Behavior, 11*, 239-249.

Hare, B., Brown, M., Williamson, C., & Tomasello, M. (2002). The domestication of social cognition in dogs. *Science, 298*, 1634-1636.

Hare, B., & Tomasello, M. (1999). Domestic Dogs (*Canis familiaris*) use human and conspecific social cues to locate hidden food. *Journal of Comparative Psychology, 113*, 173-177.

Hepper, P.G. (1988). The discrimination of human odour by the dog. *Perception, 17*, 549-554.

Honey, R.C., & Watt, A. (1999). Acquired relational equivalence between contexts and features. *Journal of Experimental Psychology: Animal Behavior Processes, 25*, 324-333.

Kalmus, H. (1955). The discrimination by the nose of the dog of individual human odours and in particular the odours of twins. *Animal Behaviour, 3*, 25-31.

Kehoe, E.J., & Gormezano, I. (1980). Configuration and combination laws in conditioning with compound stimuli. *Psychological Bulletin, 87*, 351-378.

Klein, S.B. (2002). *Learning principles and applications* (4th ed.). New York: McGraw-Hill.

Larson, J., & Sieprawska, D. Automated study of simultaneous-cue olfactory discrimination learning in adult mice. *Behavioral Neuroscience, 116*, 588-599.

Leonard, J.A., Wayne, R.K., Wheeler, J., Valadez, R., Guillen, S., & Vila, C. (2002). Ancient DNA evidence for Old World origin of New World dogs. *Science, 298*, 1613-1615.

Liinamo, A.E., Karjalainen, L., Ojala, M., & Vilva, V. (1997). Estimates of genetic parameters and environmental effects for measures of hunting performance in Finnish Hounds. *Journal of Animal Science, 75,* 622-629.

Lober, K., & Lachnit, H. (2002). Configural learning in human Pavlovian conditioning: Acquisition of a biconditional discrimination. *Biological Psychology, 59,* 163-168.

Mackenzie, S.A., Oltenacu, E.A.B., & Houpt, K.A. (1986). Canine behavioral genetics: A review. *Applied Animal Behaviour Science, 15,* 365-393.

Mackintosh, N.J. (1975). A theory of attention: Variations in the associability of stimuli with reinforcement. *Psychological Review, 82,* 276-298.

Maes, J.H.R., & deGroot, G. (2002). Effects of noise on the performance of rats in an operant discrimination task. *Behavioural Processes, 61,* 57-68.

McKinley, S., & Young, R.J. (2003). The efficacy of the model-rival method when compared with operant conditioning for training domestic dogs to perform a retrieval-selection task. *Applied Animal Behaviour Science, 2017*, 1-9.

Miklosi, A., Kubinyi, E., Topal, J., Gacsi, M., Viranyl, Z., & Csanyi, V. (2003). A simple reason for a big difference: Wolves do not look back at humans, but dogs do. *Current Biology, 13*, 763-766.

Mostofsky, S.H., Schafer, J.G.B., Abrams, M.T., Goldberg, M.C., Flower, A.A., Boyce, A., et al. (2003). fMRI evidence that the neural basis of response inhibition is task-dependent. *Cognitive Brain Research, 17*, 419-430.

Murphree, O.D., & Dykman, R.A. (1965). Litter patterns in the offspring of nervous and stable dogs I: Behavioral tests. *Journal of Nervous and Mental Disorders, 141*, 321-332.

Otto J., Brown, M.F., & Long, W. (2002). Training rats to search and alert on contraband odors. *Applied Animal Behaviour Science, 77*, 217-232.

Pearce, J.M., & Hall, G. (1980). A model for Pavlovian learning: Variations in the effectiveness of conditioned but not of unconditioned stimuli. *Psychological Review, 87*, 532-552.

Pearce, J.M., & Wilson, P.N. (1990). Configural associations in discrimination learning. *Journal of Experimental Psychology: Animal Behavior Processes, 16*, 250-261.

Pepperberg, I.M. (1999). *The Alex studies*. Cambridge, MA: Harvard University Press.

Pongracz, P., Miklosi, A., Kubinyi, E., Gurobi, K., Topal, J., & Csanyi, V. (2001). Social learning in dogs: the effect of a human demonstrator on the performance of dogs in a detour task. *Animal Behaviour, 62*, 1109-1117.

Pongracz, P., Miklosi, A., Kubinyi, E., Topal, J., & Csanyi, V. (2003). Interaction between individual experience and social learning in dogs. *Animal Behaviour, 65*, 595-603.

Povinelli, D.J., & Eddy, T.J. (1996). Factors influencing young chimpanzees' recognition of 'attention.' *Journal of Comparative Psychology, 110*, 336-345.

Rebmann, A., David, E., & Sorg, M.H. (2000). *Cadaver dog handbook.* Florida: CRC Press.

Rescorla, R.A. (1973). Evidence for "unique stimulus" account of configural conditioning. *Journal of Comparative and Physiological Psychology, 85*, 331-338.

Reuterwall, C., & Ryman, N. (1973). An estimate of the magnitude of additive genetic variation of some mental characters in Alstatian dogs. *Journal Hereditas, 73*, 277-284.

Rubia, K., Smith, A.B., Brammer, M.J., & Taylor, E. (2003). Right inferior prefrontal cortex mediates response inhibition while mesial prefrontal cortex is responsible for error detection. *NeuroImage, 20*, 351-358.

Russell, P. (2002). *iGenetics.* San Francisco: Pearson Education, Inc.

Saavedra, M.A. (1975). Pavlovian compound conditioning in the rabbit. *Learning and Motivation, 6*, 314-326.

Sarter, M., & Bruno, J.P. (1997). Cognitive functions of cortical acetylcholine: Toward a unifying hypothesis. *Brain Research Reviews, 23*, 28-46.

Savolainen, P., Zhang, Y., Luo, J., Lundeberg, J., & Leitner, T. (2002). Genetic evidence for an East Asian origin of domestic dogs. *Science, 298*, 1610-1612.

Sawtell E. (2003, March). Opinion. *DogTalk.* Retrieved March 30, 2003 from http://www.disasterdog.org/newsletters/dogtalk_mar2003.htm.

Schoon, G.A.A. (1996). Scent identification lineups by dogs (*Canis familiaris*): Experimental design and forensic application. *Applied Animal Behaviour Science, 49*, 257-267.

Setlow, B., Schoenbaum, G., & Gallagher, M. (2003). Neural encoding in ventral striatum during olfactory discrimination learning. *Neuron, 38*, 625-636.

Settle, R.H., Sommerville, B.A., McCormick, J., & Broom, D.M. (1994). *Animal Behaviour, 48*, 1443-1448.

Slabbert, J.M., & Rasa, O.A.E. (1997). Observational learning of an acquired maternal behaviour pattern by working dog pups: An alternative training method? *Applied Animal Behaviour Science, 53*, 309-316.

Sommerville, B.A., Settle, R.H., Darling, F.M.C., & Broom, D.M. (1993). The use of trained dogs to discriminate human scent. *Animal Behaviour, 46*, 189-190.

Soproni, K., Miklosi, A., Topal, J., & Csanyi, V. (2001). Comprehension of human communicative signs in pet dogs (*Canis familiaris*). *Journal of Comparative Psychology, 115*, 122-126.

Soproni, K., Miklosi, A., Topal, J., & Csanyi, V. (2002). Dogs' (*Canis familiaris*) responsiveness to human pointing gestures. *Journal of Comparative Psychology, 116*, 27-34.

Stevenson, R.J., Case, T.I., & Boakes, R.A. (2003). Smelling what *was* there: Acquired olfactory percepts are resistant to further modification. *Learning and Motivation, 34*, 185-202.

Sutherland, R.J., & Rudy, J.W. (1989). Configural association theory: The role of the hippocampal formation in learning, memory, and amnesia. *Psychobiology, 17*, 129-144.

Syrotuck, W.G. (1972). *Scent and the scenting dog.* New York: Arner Publications, Inc.

Taslitz, A.E. (1990). Does the cold nose know? The unscientific myth of the dog scent lineup. *Hastings Law Journal, 42*, 15-134.

Tomasello, M., Call, J., & Gluckman, A. (1997). Comprehension of communicative signs by apes and human children. *Child Development, 68,* 1067-1081.

Triana, E., & Pasnak, R. (1981). Object permanence in cats and dogs. *Animal Learning & Behavior, 9*, 135-139.

Vauclair, J. *Animal cognition*. Massachusetts: Harvard University Press.

Vaughter, R.M., Smotherman, W., & Ordy, J.M. (1972). Development of object permanence in the infant squirrel monkey. *Developmental Psychology, 7,* 34-38.

Watanabe, Y., Gould, E., & McEwen, B.S. (1992). Stress induces atrophy of apical dendrites of hippocampal CA3 pyramidal neurons. *Brain Research, 588,* 341-345.

Weiss, E., & Greenberg, G. (1997). Service dog selection tests: Effectiveness for dogs from animal shelters. *Applied Animal Behaviour Science, 53*, 297-308.

Wells, D.L., & Hepper, P.G. (2003). Directional tracking in the domestic dog, *Canis familiaris. Applied Animal Behaviour Science, 84*, 297-305.

Williams, D.A., Sagness, K.E., & McPhee, J.E. (1994). Configural and elemental strategies in predictive learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20, 694-709.

Williams, M., & Johnston, J.M. (2002). Training and maintaining the performance of dogs (*Canis familiaris*) on an increasing number of odor discriminations in a controlled setting. *Applied Animal Behaviour Science, 78*, 55-65.

Willis, M.B. (1989). *Genetics of the dog.* Howell Book House: New York.

Wilsson, E., & Sundgren, P.E. (1997a). The use of a behaviour test for the selection of dogs for service and breeding, I: Method of testing and evaluating test results in the adult dog, demands on different kinds of service dogs, sex and breed differences. *Applied Animal Behaviour Science, 53*, 279-295.

Wilsson, E., & Sundgren, P.E. (1997b). The use of a behaviour test for selection of dogs for service and breeding, II: Heritability for tested parameters and effect of selection based on service dog characteristics. *Applied Animal Behaviour Science, 54*, 235-241.

Wilsson, E., & Sundgren, P.E. (1998). Behaviour test for eight-week old puppies - heritabilities of tested behaviour traits and its correspondence to later behaviour. *Applied Animal Behaviour Science, 58*, 151-162.

Wise, K.L., Wise, L.A., & Zimmermann, R.R. (1974). Piagetian object permanence in the infant rhesus monkey. *Developmental Psychology, 10*, 429-437.

Wood, S., Moriarty, K.M., Gardner, B.T., & Gardner, R.A. (1980). Object permanence in child and chimpanzee. *Animal Learning & Behavior, 8*, 3-9.

Woodbury, C.B. (1943). The learning of stimulus patterns by dogs. *Journal of Comparative and Physiological Psychology, 35*, 29-40.

Zucco, G.M. (2003). Anomalies in cognition: Olfactory memory. *European Psychologist, 8*, 77-86.